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Arthur Schuster.

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Victoria university, Manchester, Eng.

The

Physical Laboratories

of the

University of Manchester

A Record of 25 Years' Work

Prepared in Commemoration of the 25th Anniversary of the Election of Dr. Arthur Schuster, F.R.S., to a Professorship in the Owens College, by his old Students and Assistants.

MANCHESTER
AT THE UNIVERSITY PRESS
1906

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No. XIII.

PREFACE.

THE main object in view in preparing this little volume has been to provide as complete an account as possible of the work which has been carried out under Professor Schuster's direction during the past twenty-five years. It has not been thought necessary, however, to enter at length into the earlier history of the department, since this has been so ably dealt with in the volume on the Owens College by Dr. Joseph Thompson[1] and Mr. P. J. Hartog.[2]

For the first few years of the period covered, Dr. Schuster held the Professorship of Applied Mathematics, and was appointed to the chair of Physics only after the death of Professor Balfour Stewart, but even a cursory glance at the list of his publications will serve to show the interest which he has taken throughout in both the experimental and mathematical branches of the subject.

The difficulties of making such a record complete will, it is hoped, be sufficiently apparent to excuse many of the omissions.

1. "The Owens College: Its Foundation and Growth and its Connection with the Victoria University, Manchester." By Joseph Thompson. Manchester: Cornish, 1886.

2. "The Owens College, Manchester: A Brief History of the College and Description of its various Departments." By P. J. Hartog, B.Sc. Manchester: Cornish, 1900.

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Plan I. Basement.
„ II. Ground Floor.
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„ IV. Second Floor.

(From the Architect's Drawing)

Fig. I. THE PHYSICAL LABORATORIES.

i. Description of Equipment for Instruction and Research.

i. Description of Equipment for Instruction and Research.

INTRODUCTION.

The first practical laboratory work in Physics at the Owens College was organised by the late Professor Balfour Stewart on his election to the Chair of Physics in the year 1870, the laboratory being opened in the Session 1871-2.

The following numbers will illustrate the rapid growth of the department since that date.

1871-72.	Number of	students	attending	the	Phys. Lab.	8
1875-76.	,,	,,	,,	,,	,,	13
1880-81.	,,	,,	,,	,,	,,	27
1885-86.	,,	,,	,,	,,	,,	62
1890-91.	,,	,,	,,	,,	,,	105
1895-96.	,,	,,	,,	,,	,,	183

At the present time there are about 150 students taking the 1st. M.B. and Inter. Sci. Courses, and 100 doing more advanced work.

When the Owens College was removed to Oxford Road in 1873, three rooms in the basement were assigned to the Physical Laboratory and further rooms were from time to time added, but the demand for a larger laboratory, specially designed for the purpose, became very urgent. Professor Schuster, having repeatedly drawn the Council's attention to this pressing need, and a generous donor having promised a large sum for the purpose, the Council decided to build a Physical Institute on a plot of land on the north side of Coupland Street, adjacent to the main College buildings.

Particulars of the donations received towards the establishment of the new laboratories are given in Appendix I.

Dr. Schuster devoted a large amount of time and thought to every detail of the design and equipment of the Physical Institute, and those who have worked in it can testify that little has been omitted which could add to its efficiency and comfort.

The foundation stone of the new laboratories was laid by the late Mr. Henry Simon, on October 4th, 1898, and the buildings were formally opened by Lord Rayleigh on June 29th, 1900.

The general appearance of the building, of which Mr. J. W. Beaumont, F.R.I.B.A., of Manchester, was the architect, may be judged from the drawing reproduced in Fig. I. It is built of red Ruabon brick, faced with stone. Nearly all the rooms are lined with white and brown glazed bricks, which, although adding somewhat to the cost of the building, greatly facilitate keeping the laboratory in a clean and bright condition. The walls of the corridors and stairs are relieved by a dado of blue glazed tiles.

In the following brief account of the equipment no attempt has been made to enter into a detailed description of the laboratory, but attention is drawn to some of its special features.

The plans of the different floors, which are reproduced, will enable the general arrangement to be understood. As several descriptions of newly erected physical laboratories have recently been published, it is only necessary to describe such parts of the equipment as have reference to the special lines of work which have been taken up, and thus put on record some phases of the laboratory's activity.

Considered broadly, it may be said that the first floor is devoted to the general instruction in practical physics, the ground floor to electrical engineering and electro-chemistry,

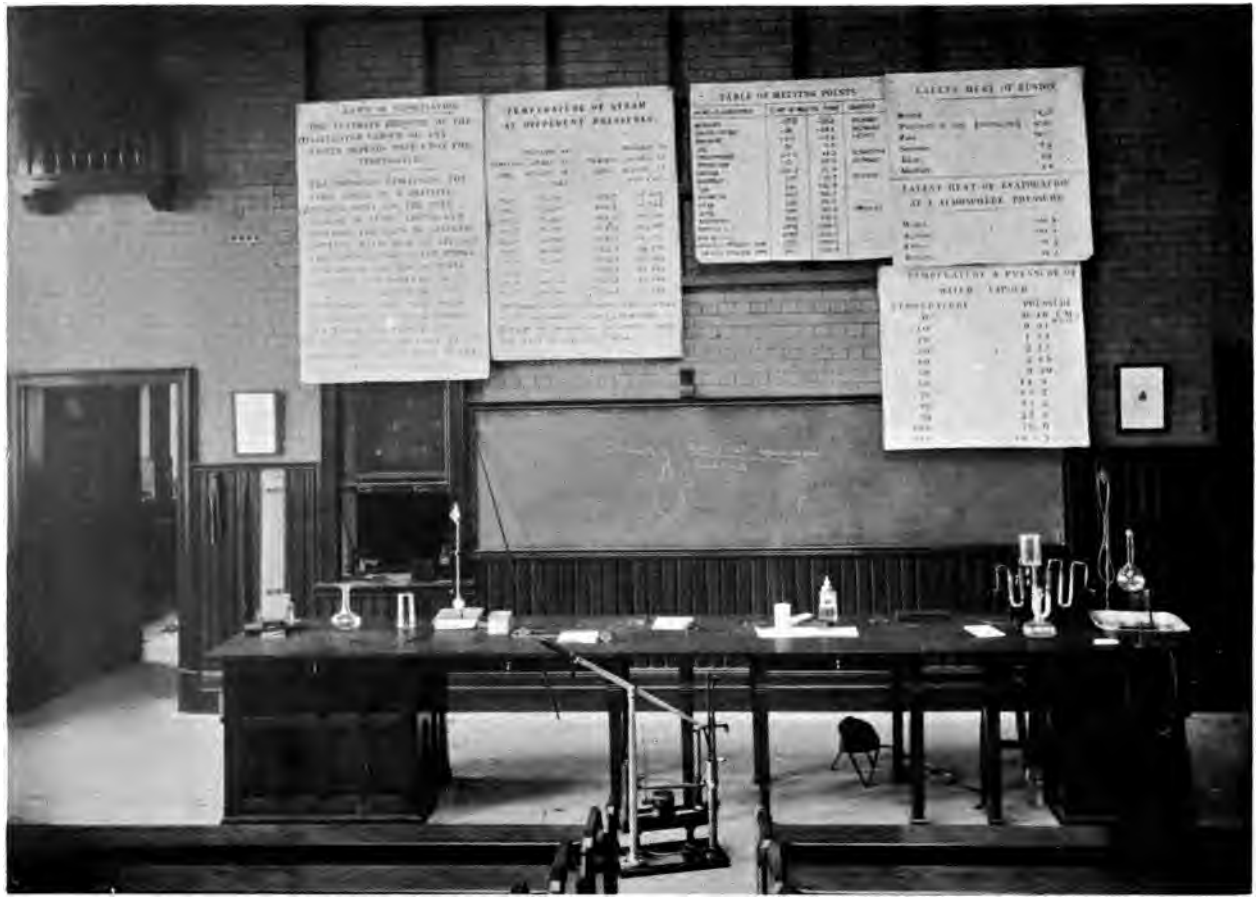

Fig. II. PHYSICS LECTURE THEATRE.

and the second floor and basement mainly to research purposes. The lecture rooms are also situated on the second floor. The large theatre can comfortably seat 200; whilst a smaller room has been provided for advanced lectures, in which the numbers do not exceed 25. This is equipped with portable American class room chairs, which make it possible to use the room for other purposes if necessary.

A small astronomical observatory, containing a 10 inch refracting telescope by T. Cooke & Sons, of York, the gift of Sir Thomas Bazley, Bart., has been erected on the roof.

LABORATORIES FOR INSTRUCTION IN PRACTICAL PHYSICS.

As previously mentioned, these are situated on the first floor. The largest room (36 ft. × 48 ft.) is used chiefly for the Intermediate B.Sc. and 1st M.B. Classes, which are held three times a week. It is termed the Elementary Laboratory, although some of the advanced work is also carried out here. The various sets of apparatus used by the students are kept in cupboards and drawers under the working benches. The slate slabs along the northern wall are intended for calorimetric and similar work.

This room, in common with many other parts of the laboratory, is supplied with water, gas, steam for experimental purposes, and compressed air, which are conveyed by a series of pipes, coloured differently to enable them to be easily distinguished.

Leading out of the Elementary Laboratory are a Balance Room, which contains the delicate balances used for more advanced physical exercises, and a room for Electrical Measurements. The latter contains a sectional switchboard similar in construction to the main distribution board on the ground floor (see p. 17), and used for sub-dividing the supply of

experimental current on the first and second floors.

Some of the mirror galvanometers are arranged on slate slabs round the walls so that the students may examine and adjust them readily; whilst space is saved by fixing others on high brackets on the walls, with the scales about a metre below them. The beam of light is reflected on the scale by means of an adjustable mirror. This system was first introduced by Siemens & Halske, of Berlin. A Kelvin Balance is also mounted in this room.

A second Electrical Laboratory, a large well ventilated room for optical work, and a room for sound and general physics complete the teaching accommodation of this floor.

The Optical Room, which is used for measurements with spectrometers, spectroscopes, optical benches, polarimeters, etc., is provided with dark blinds and has its walls coloured with Venetian red, which serves the same purpose as black without being so gloomy.

A balcony at the end of the corridor and close to this room serves for adjusting telescopes, and for practice with the sextant.

The following account of the organisation of the practical instruction in Physics will doubtless be of interest. The system, which has been gradually developed, enables the co-ordination and supervision of the work of a large number of students to be carried out with the help of comparatively few assistants.

It is scarcely necessary to add that, although the text-books which are in use have been specially written to suit the requirements of the department, the more advanced students, and those desirous of following special courses, are allowed considerable latitude, and carry out a number of exercises and measurements not included in the text-books.

In this way the disadvantages of too stereotyped a course are efficiently guarded against.

ORGANISATION OF STUDENTS' LABORATORY WORK.

The students taking practical physics are divided into three classes (1) the Inter. B.Sc. and First M.B. Class, (2) the Final B.Sc. and First Year's Honours Class, and (3) the Second and Third Years' Honours Class.

Each student on entering for a practical class pays a deposit fee of £1 1s. 0d. which is returned to him at the end of the Session, after the cost of any apparatus he may have damaged has been deducted.

An *Intermediate B.Sc. or First M.B. student* on commencing work in the laboratory receives a copy of the following regulations :—

PHYSICAL LABORATORIES.

INTERMEDIATE B.Sc. AND 1ST M.B. PRACTICAL PHYSICS COURSE.

REGULATIONS.

I. Each student should be provided with the Intermediate Practical Physics text-book and with two note books.

(1) A note book in which to record observations as they are taken, and to make rough calculations. This note book must be available for inspection when required. No observations are to be taken or calculations made on loose sheets of paper.

(2) A note book in which to write out carefully the method of working and the results obtained. The pages of this book should be divided into squares. For the sake of uniformity, students should obtain the note books supplied in the Laboratory.

II. He will find it convenient to be provided also with the following instruments :—pen and pencil compass, boxwood

rule having diagonal and protractor scales, and a six-inch steel rule divided into millimetres and inches.

III. Each student is responsible for the apparatus he is using, and all pieces of apparatus must, unless special permission to the contrary is obtained, at the end of the class, be left in the same condition, and in the same place, in which they were found.

IV. Each piece of apparatus is numbered. Students must enter in their note books the number of each piece they have in use. Students failing to comply with this regulation are liable to be made responsible for any damage which cannot be traced to its author.

V. Students are not allowed to proceed to another exercise until their previous work has been approved by the Professor or Demonstrator in charge of the class. A description of the approved exercise and results should be written in the second note book, and shown to the Professor or Demonstrator in charge, on days which will be announced on the notice board in the Laboratory.

VI. This second or principal note book will be examined from time to time. A Professor's Note Book Prize will be awarded, and a student's position in the class list at the end of the session will to some extent depend on the result of this examination.

The Intermediate B.Sc. and First M.B. class numbers about 150, and is divided into three divisions which work in the large Elementary Laboratory for two hours on Monday, Friday, and Saturday mornings respectively. The apparatus used by them is of simple construction, and about a dozen sets of each piece of apparatus are provided, so that the students may work independently. The experiments carried out by this class are described in Schuster and Lees's "Intermediate Course of Practical Physics," (Macmillan). The

Work Card—Physical Laboratories—University of Manchester.

Name ..... *Course* ..... *When present* .....

Exercise.			Date.		Exercise.			Date.		Exercise.			Date.	
No.	Name.	App.	Commcd.	Finishd.	No	Name.	App.	Commcd.	Finishd.	No	Name.	App.	Commcd.	Finishd
4	Level				31	Syren				58	P.O. Box			
5	Tube				32	Kundt.				59	High R.			
7	Weight				33	Lissj.				60	Low R.			
8	Density				35	Sxtnt.				61	R. Galv.			
9	do.				36	Curvat.				62	R. Cell			
11	Inertia				37	Tot. Ref.				63	C. Foster			
13	Pend.				38	Mag. Pwr.				64	Tmp. Coef.			
14	Beams				39	Specscop.				65	R. Electl.			
15	Rigdty.				40	do.				66	Clark cell.			
16	Viscty.				41	Specmtr.				67	Com. EMF			
17	Sur. Tens.				42	R.I. gls.				68	Potntr.			
18	Exp. Solid.				43	R.I. liq.				69	Thermo.			
19	do. Liq.				44	Phtmty.				70	Mech. Eq.			
20	Pres. Coef.				45	Interfce.				71	Indctn.			
21	Exp. Gas.				46	Diff. Grt.				72	Ind. of Cl.			
22	P. & B.P.				47	Polrtr.				73	Abs. Cnds.			
23	Hygr.				48	do.				74	Use Cnds.			
24	Coolng.				49	Mag. Fld.				75	Cap. Cnds.			
25	Caltry.				50	Survey								
26	Spc. Ht.				52	Cur. Met.								
27	Lat. Ht.				53	Ohm's law								
28	do.				54	Cells								
29	Ht. Soltn.				55	Wat. Volt.								
30	Mech. Eq.				56	Cu. Volt.								

results are written out neatly by the students in note books provided with squared paper, on which curves and diagrams can be drawn. These note books are examined regularly, and the records contained in them are taken into account in determining the class list at the end of the session. Professor Schuster has since this system was established offered an annual prize awarded to the student who presents the best kept note book.

The Final B.Sc. and First Year's Honours students number about 60. As a rule they take two days a week in the laboratory, and work through the experiments described in Schuster and Lees's "Advanced Exercises in Practical Physics," (Cambridge University Press). Each student is furnished with a copy of the following regulations and with a diary card which is reproduced as a plate.

PHYSICAL LABORATORIES.

REGULATIONS.

The following regulations apply to students working in the Physical Laboratories, other than those attending the Intermediate B.Sc., and 1st M.B. Practical Class, and those doing special work.

I. NOTE BOOKS.

Each student must be provided with the following :—

1. *A Diary Card.*

On this card, students must, after each attendance, enter a statement of the work they have done. *This card should be placed in the box specially provided for it and should never be taken from the laboratory.* For non-observance of this rule a fine will be enforced.

2. *A Book of Observations.*

Observations should never be recorded on loose sheets, but in a book of observations, with sufficient detail to enable students at any future time to know at once the meaning of all entries.

Students will find the care bestowed on the systematic entry of their observations of the greatest value in their future work.

3. *Two Results Note Books.*

In these, the method of taking and reducing the observations, and the results obtained, should be written out carefully. The exercises should be recorded in these books alternately, so that while one of them is left at the Laboratory for inspection, the other is available for writing out a fresh set of exercises.

Students are strongly recommended to write out each exercise before proceeding to another. They will not be considered to have *completed* an exercise until a full account has been handed in and approved, and under no circumstances will students be allowed to undertake fresh work while more than one exercise is in an incomplete state.

All Note Books must have the names of the students written on the *outside.* For the sake of uniformity, students should use the books sold in the Laboratory for this purpose. In fixing the Class Lists at the end of the session, considerable importance will be attached to the manner in which the books are kept.

Each student should also be provided with drawing instruments and a copy of Lupton's Tables and Constants.

II. General Regulations.

Students should enter and leave the laboratory as nearly as possible at the times fixed at the beginning of the session. If absent without permission, during part of the time they

should be working in the laboratory, they are liable to be marked absent for the whole morning or afternoon.

Students should not touch any apparatus without authority, as considerable damage may unintentionally be done.

They should not, after use, remove any large pieces of apparatus they found set up, but smaller pieces which have been supplied to them from the cupboards should be returned to one of the Demonstrators, and all burners, tubing, wire, etc., should be returned to the drawers set apart for them.

Students may get to know the previous afternoon what exercise they are to do the following day, and are expected to prepare for their work by reading at home the theory of the subject.

III. Fines.

No charge is made for the ordinary wear and tear of apparatus but students must make good any damage due to gross carelessness or neglect. Students who find any part of the apparatus supplied to them damaged, or missing, must at once report to one of the Demonstrators, otherwise they are liable to be made responsible for the damage.

It has been found necessary to introduce a system of fines, in order to secure greater care in the handling of apparatus. A list of the various offences for which fines, varying from 3d. to 2s., are imposed, is suspended in the laboratory. On a second list the names of students are entered, together with the fines to which they have rendered themselves liable. Any appeal should be addressed to the Director of the Laboratory, not later than a week after the fine, which they wish to have removed, has been entered against their name.

The proceeds from fines will be used to increase the reference library of the laboratory.

Every student is provided with a "Diary Card," and when given an experiment to perform, he makes a note of the date in that column of this card which is marked "commenced," and the letter or number of the set of apparatus provided for the experiment, in the column marked "App." When he has completed the experiment, and his results are considered satisfactory by one of the Demonstrators, he enters the date in the column "finished." These diary cards are kept in a box on the Demonstrators' table, and shew at a glance which exercises a student has completed. By referring to these cards the Demonstrators can assign the next experiment to be performed. The list of these experiments is entered in a "Day Book" on the day previous to that of the students' attendance, in order that they may read up the subject and make themselves familiar with the theory of the experiment.

The results of all the experiments are written out neatly, and are examined from time to time by the Director of the Laboratory. The records in these note books are taken into account in the class lists at the end of the session.

Second Year's Honours students are engaged in doing more advanced work in Optics and Electricity in connection with the lecture courses of their year, and Third Year's Honours students are, in general, engaged in research work.

Electrical Engineering and Chemical Honours students as a rule go through the Intermediate Practical Physics Course in their first year, and a certain number of exercises of the Final B.Sc. course, along with a number of special exercises in their second year.

WORKSHOP AND INSTRUMENT MAKING.

Mr. James Griffiths, the Steward of the Laboratory, has for many years rendered most valuable assistance in the construction and repair of experimental apparatus. In the new buildings two rooms have been reserved for the workshop accommodation and have been suitably equipped.

A recent valuable addition to the resources of the laboratory has been the establishment in its immediate vicinity, of the University Engineering Works. Mr. Chas. W. Cook who, under the patronage of the University, has started these works, has had considerable experience in the construction of research apparatus whilst connected with the Davy Faraday Laboratory of the Royal Institution.

Similarly the laboratory is very fortunate in the close proximity of the Glass Blowing Works of Mr. Otto Baumbach, whose skill in constructing apparatus of glass and quartz has proved of great service in many investigations.

FELLOWSHIPS AND SCHOLARSHIPS ATTACHED TO THE PHYSICAL LABORATORIES.

In addition to a number of general Fellowships and Scholarships, tenable in the Physical Laboratories, particulars of which may be found in the University Calendar, the following have been founded by bequests or gifts made to the department.

John Harling Research Fellowship.

This Fellowship was founded in 1900 in connection with the new laboratories, by a donation of £5,000 from Mr. R. H. Gibson and Mr. R. P. Blakeley, as legatees of the late Mr. John Harling. It is intended to encourage research in Physical Science, to which the Fellow is required to devote his whole time during the tenure of the Fellowship.

Former John Harling Fellows.

1900-1903. J. E. Petavel.
1903-1906. W. Makower.

Heginbottom Scholarship.

Founded, in 1875 by the late Mr. George Heginbottom, of Ashton-under-Lyne and Birkdale. Is of the annual value of £15, and is awarded on the results of the annual class examinations of the First Year's Honours Course in Physics.

Hatfield Scholarship.

Founded by a bequest of the late Mr. John Hatfield of Manchester and Colwyn Bay, in 1905. This scholarship is of the annual value of about £35, and is awarded at the end of the second year of the Honours Course in Physics, being tenable for one or two years.

ELECTRICAL ENGINEERING.

The success of the modest equipment for Electrical Engineering in connection with the old Physical Laboratories, and the recognition of the demand for higher educational facilities in this subject in such an important electrical centre as Manchester, led the University authorities to make provision for Electrical Engineering on a much more ambitious scale in the new Physical Buildings.

Already in the old laboratory, many men now occupying important positions in the Electrical Engineering profession, received their training under Dr. C. H. Lees, who then had charge of the Electrical Engineering classes.

With the organisation of the department on a larger scale, a separate lectureship on Electrical Engineering was created and Dr. R. Beattie was appointed to the post. A steady and rapid growth of the number of students in this subject

can be recorded, and, with improved facilities, it has been possible to take up advanced work and research. In both the Honours Schools of Engineering and Physics the subject is now recognised by the University, whilst a course preparing for the Certificate in Electrical Engineering has also been organised.

The belief that there is ample scope for the treatment of the higher branches of this subject theoretically and practically in an advanced manner, even if comparatively few students avail themselves of it, has been fully justified; sufficient provision being made at the Manchester School of Technology for such classes as appeal to the large number of students wishing to follow up the more usual lines of training in this subject.

Of the wisdom of associating Electrical Engineering with Physics under the same roof, little need be said. Apart from evident economies in lecture room and workshop accommodation—lecture rooms fitted up for Physics work requiring but little additional equipment to render them peculiarly well adapted for Electrical Engineering purposes, and the same workshop serving equally well for both departments—the association is mutually beneficial in manifold directions. For a Physical Laboratory to have the resources of an Electrical Engineering department always at hand, and a supply of direct and alternating current together with electrical measuring and standardizing instruments always available, is in itself a luxury; but where, as at the Manchester University, a large amount of advanced electrical and other research is done, the association is little short of a necessity.

The total floor space set apart for the Electrical Engineering Laboratories in the new buildings amounts to over 6,000 square feet, but no serious attempt was made to fully equip the whole of this at the outset; only sufficient plant was

put down to enable students to obtain a thorough grounding in the testing and working of electrical machinery and apparatus of modern types. The original equipment, has, however, been constantly added to as opportunity afforded, the ultimate equipment of the laboratories for work of the very highest kind having always been kept in view.

Dynamo House.

The Hopkinson Memorial Wing, built and equipped by funds provided by relatives and friends of the late Dr. John Hopkinson, contains a Dynamo House, Accumulator Room, Photometer Room, and the Electro-Chemical Laboratory.

The dynamo house, two views of which are given (Figures IV and V) is a spacious well-lighted building, 56 feet long by 27 feet wide, fitted with seventeen examples of different types of direct and alternating-current generators and motors, of outputs ranging up to 25 H.P. Of these machines the generators are mounted on rails running the whole length of the room, and are driven by belts from a line of shafting in the room immediately underneath, an arrangement, suggested by a similar one at the Technical School, Hanover, which allows easy access to the machinery from any side. Power is supplied to the shafting, at one end by a high-speed gas engine, the gift of Mr. W. J. Crossley, M.P., direct coupled through a friction clutch to the shaft, and at the other by a belt from a 25 H.P. direct-current motor, presented by the British Westinghouse Co., driven off the public supply. The shafting is divided in the centre by a claw clutch so that one half can be driven independently by the motor, or both gas engine and motor may be used conjointly to supply power to any particular set of machines. The larger generator units are belted to the engine-driven half of the shaft and

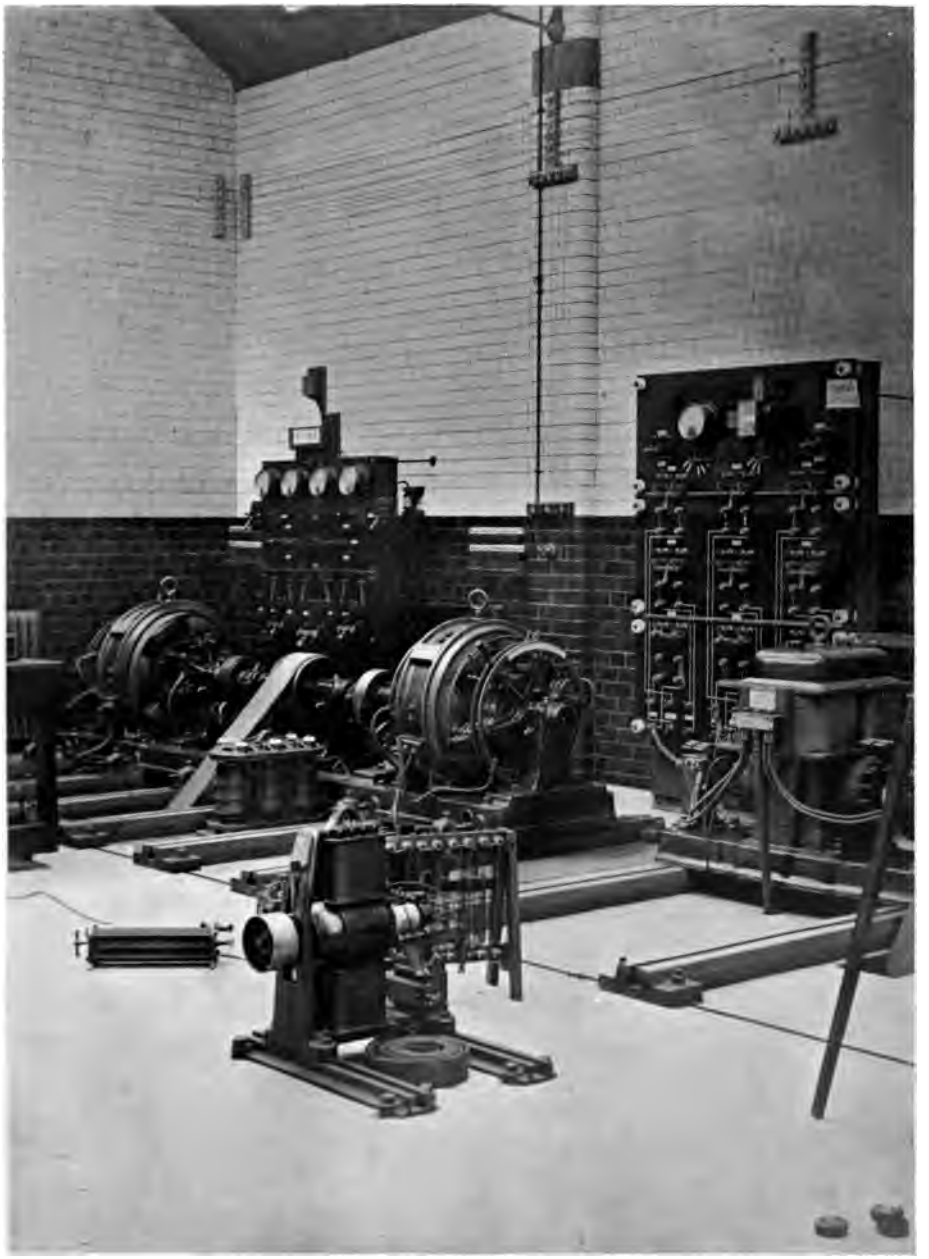

Fig. IV. DYNAMO HOUSE (View I.)

serve as general supply machines for the whole Laboratory, being connected up to a distribution board from which current can be sent to any part of the building. For convenience, arrangements are made whereby the voltage of any of these machines also can be regulated from the Electro-Chemical Laboratory.

Amongst the larger generator units are a pair of similar direct-current shunt machines, each of 18 K.W. output, specially mounted on a combined bed-plate and coupled by friction clutches. These machines are also fitted with slip-rings, enabling them to be used at will as 3-phase generators, synchronous motors, or rotary convertors, so that, in addition to forming the main source of supply of high-voltage direct current for experimental work—as well as for cell charging and lighting, in the event of the public supply failing—they constitute a valuable set on which "Hopkinson" and a great variety of other tests can be carried out.

A supply of low-voltage current for the Electro-Chemical Laboratory is likewise provided for in this room by a 15 K.W. "Castle" dynamo of the double-commutator type, capable of delivering 500 amperes at 30 volts or 1000 amperes at 15 volts, according as the armature halves are in series or parallel.

Mention should also be made of a pair of machines specially built for educational work, and presented by Messrs. Mather and Platt, Ltd. One of these is an 18 K.W. single-phase alternator with a rotating armature, the sections of which can be grouped in different ways so as to vary the current output over a wide range. The other is a 12 K.W. rotating-field polyphase alternator, having an armature ring-wound with six independent phases, which are connected to six separate pairs of terminals, thus permitting a large number of different combinations to be formed, and the machine to be used as a single- two- or three-phaser.

Of special interest, too, are a pair of similar single-phase Wilde machines, representing one of the earliest types of commercially successful alternator. These were presented to the Laboratories by Dr. Henry Wilde, F.R.S. for the purpose of illustrating the property of synchronous running, originally discovered by him.

The smaller generator units—used almost exclusively for testing work—are belted to the motor-driven half of the shaft for the sake of better speed control, whilst the motor units, also small machines mostly intended to be driven from storage cells, are mounted, each on a separate brickwork pillar, at a convenient height from the floor, and fitted with various types of brakes.

Besides the foregoing plant, the Dynamo House is liberally supplied with needful accessory apparatus in the way of single and polyphase transformers; resistances for regulating and power absorption purposes; and measuring instruments, fixed and portable.

A room in the basement in the same wing as the Dynamo House makes a convenient Photometric Gallery. A nucleus of the equipment of this has already been formed, and with the addition of a few of the later modern appliances, photometric work of any kind on arc and incandescent lamps will be capable of being dealt with.

Accumulator Room.

In order to shorten heavy-current connections, this room is conveniently situated in close proximity to the Dynamo House, the Electro-Chemical Laboratory, and the Standardizing Room, where the largest current demand from the cells occurs. It contains two separate batteries, one of 34 cells, presented by the Chloride Electric Storage Co., and another,

Fig. V. DYNAMO HOUSE (View II).

2. *A Book of Observations.*

Observations should never be recorded on loose sheets, but in a book of observations, with sufficient detail to enable students at any future time to know at once the meaning of all entries.

Students will find the care bestowed on the systematic entry of their observations of the greatest value in their future work.

3. *Two Results Note Books.*

In these, the method of taking and reducing the observations, and the results obtained, should be written out carefully. The exercises should be recorded in these books alternately, so that while one of them is left at the Laboratory for inspection, the other is available for writing out a fresh set of exercises.

Students are strongly recommended to write out each exercise before proceeding to another. They will not be considered to have *completed* an exercise until a full account has been handed in and approved, and under no circumstances will students be allowed to undertake fresh work while more than one exercise is in an incomplete state.

All Note Books must have the names of the students written on the *outside*. For the sake of uniformity, students should use the books sold in the Laboratory for this purpose. In fixing the Class Lists at the end of the session, considerable importance will be attached to the manner in which the books are kept.

Each student should also be provided with drawing instruments and a copy of Lupton's Tables and Constants.

II. General Regulations.

Students should enter and leave the laboratory as nearly as possible at the times fixed at the beginning of the session. If absent without permission, during part of the time they

should be working in the laboratory, they are liable to be marked absent for the whole morning or afternoon.

Students should not touch any apparatus without authority, as considerable damage may unintentionally be done.

They should not, after use, remove any large pieces of apparatus they found set up, but smaller pieces which have been supplied to them from the cupboards should be returned to one of the Demonstrators, and all burners, tubing, wire, etc., should be returned to the drawers set apart for them.

Students may get to know the previous afternoon what exercise they are to do the following day, and are expected to prepare for their work by reading at home the theory of the subject.

III. Fines.

No charge is made for the ordinary wear and tear of apparatus but students must make good any damage due to gross carelessness or neglect. Students who find any part of the apparatus supplied to them damaged, or missing, must at once report to one of the Demonstrators, otherwise they are liable to be made responsible for the damage.

It has been found necessary to introduce a system of fines, in order to secure greater care in the handling of apparatus. A list of the various offences for which fines, varying from 3d. to 2s., are imposed, is suspended in the laboratory. On a second list the names of students are entered, together with the fines to which they have rendered themselves liable. Any appeal should be addressed to the Director of the Laboratory, not later than a week after the fine, which they wish to have removed, has been entered against their name.

The proceeds from fines will be used to increase the reference library of the laboratory.

Every student is provided with a "Diary Card," and when given an experiment to perform, he makes a note of the date in that column of this card which is marked "commenced," and the letter or number of the set of apparatus provided for the experiment, in the column marked "App." When he has completed the experiment, and his results are considered satisfactory by one of the Demonstrators, he enters the date in the column "finished." These diary cards are kept in a box on the Demonstrators' table, and shew at a glance which exercises a student has completed. By referring to these cards the Demonstrators can assign the next experiment to be performed. The list of these experiments is entered in a "Day Book" on the day previous to that of the students' attendance, in order that they may read up the subject and make themselves familiar with the theory of the experiment.

The results of all the experiments are written out neatly, and are examined from time to time by the Director of the Laboratory. The records in these note books are taken into account in the class lists at the end of the session.

Second Year's Honours students are engaged in doing more advanced work in Optics and Electricity in connection with the lecture courses of their year, and Third Year's Honours students are, in general, engaged in research work.

Electrical Engineering and Chemical Honours students as a rule go through the Intermediate Practical Physics Course in their first year, and a certain number of exercises of the Final B.Sc. course, along with a number of special exercises in their second year.

WORKSHOP AND INSTRUMENT MAKING.

Mr. James Griffiths, the Steward of the Laboratory, has for many years rendered most valuable assistance in the construction and repair of experimental apparatus. In the new buildings two rooms have been reserved for the workshop accommodation and have been suitably equipped.

A recent valuable addition to the resources of the laboratory has been the establishment in its immediate vicinity, of the University Engineering Works. Mr. Chas. W. Cook who, under the patronage of the University, has started these works, has had considerable experience in the construction of research apparatus whilst connected with the Davy Faraday Laboratory of the Royal Institution.

Similarly the laboratory is very fortunate in the close proximity of the Glass Blowing Works of Mr. Otto Baumbach, whose skill in constructing apparatus of glass and quartz has proved of great service in many investigations.

FELLOWSHIPS AND SCHOLARSHIPS ATTACHED TO THE PHYSICAL LABORATORIES.

In addition to a number of general Fellowships and Scholarships, tenable in the Physical Laboratories, particulars of which may be found in the University Calendar, the following have been founded by bequests or gifts made to the department.

John Harling Research Fellowship.

This Fellowship was founded in 1900 in connection with the new laboratories, by a donation of £5,000 from Mr. R. H. Gibson and Mr. R. P. Blakeley, as legatees of the late Mr. John Harling. It is intended to encourage research in Physical Science, to which the Fellow is required to devote his whole time during the tenure of the Fellowship.

Former John Harling Fellows.

1900-1903. J. E. Petavel.
1903-1906. W. Makower.

Heginbottom Scholarship.

Founded, in 1875 by the late Mr. George Heginbottom, of Ashton-under-Lyne and Birkdale. Is of the annual value of £15, and is awarded on the results of the annual class examinations of the First Year's Honours Course in Physics.

Hatfield Scholarship.

Founded by a bequest of the late Mr. John Hatfield of Manchester and Colwyn Bay, in 1905. This scholarship is of the annual value of about £35, and is awarded at the end of the second year of the Honours Course in Physics, being tenable for one or two years.

ELECTRICAL ENGINEERING.

The success of the modest equipment for Electrical Engineering in connection with the old Physical Laboratories, and the recognition of the demand for higher educational facilities in this subject in such an important electrical centre as Manchester, led the University authorities to make provision for Electrical Engineering on a much more ambitious scale in the new Physical Buildings.

Already in the old laboratory, many men now occupying important positions in the Electrical Engineering profession, received their training under Dr. C. H. Lees, who then had charge of the Electrical Engineering classes.

With the organisation of the department on a larger scale, a separate lectureship on Electrical Engineering was created and Dr. R. Beattie was appointed to the post. A steady and rapid growth of the number of students in this subject

can be recorded, and, with improved facilities, it has been possible to take up advanced work and research. In both the Honours Schools of Engineering and Physics the subject is now recognised by the University, whilst a course preparing for the Certificate in Electrical Engineering has also been organised.

The belief that there is ample scope for the treatment of the higher branches of this subject theoretically and practically in an advanced manner, even if comparatively few students avail themselves of it, has been fully justified; sufficient provision being made at the Manchester School of Technology for such classes as appeal to the large number of students wishing to follow up the more usual lines of training in this subject.

Of the wisdom of associating Electrical Engineering with Physics under the same roof, little need be said. Apart from evident economies in lecture room and workshop accommodation—lecture rooms fitted up for Physics work requiring but little additional equipment to render them peculiarly well adapted for Electrical Engineering purposes, and the same workshop serving equally well for both departments—the association is mutually beneficial in manifold directions. For a Physical Laboratory to have the resources of an Electrical Engineering department always at hand, and a supply of direct and alternating current together with electrical measuring and standardizing instruments always available, is in itself a luxury; but where, as at the Manchester University, a large amount of advanced electrical and other research is done, the association is little short of a necessity.

The total floor space set apart for the Electrical Engineering Laboratories in the new buildings amounts to over 6,000 square feet, but no serious attempt was made to fully equip the whole of this at the outset; only sufficient plant was

put down to enable students to obtain a thorough grounding in the testing and working of electrical machinery and apparatus of modern types. The original equipment, has, however, been constantly added to as opportunity afforded, the ultimate equipment of the laboratories for work of the very highest kind having always been kept in view.

Dynamo House.

The Hopkinson Memorial Wing, built and equipped by funds provided by relatives and friends of the late Dr. John Hopkinson, contains a Dynamo House, Accumulator Room, Photometer Room, and the Electro-Chemical Laboratory.

The dynamo house, two views of which are given (Figures IV and V) is a spacious well-lighted building, 56 feet long by 27 feet wide, fitted with seventeen examples of different types of direct and alternating-current generators and motors, of outputs ranging up to 25 H.P. Of these machines the generators are mounted on rails running the whole length of the room, and are driven by belts from a line of shafting in the room immediately underneath, an arrangement, suggested by a similar one at the Technical School, Hanover, which allows easy access to the machinery from any side. Power is supplied to the shafting, at one end by a high-speed gas engine, the gift of Mr. W. J. Crossley, M.P., direct coupled through a friction clutch to the shaft, and at the other by a belt from a 25 H.P. direct-current motor, presented by the British Westinghouse Co., driven off the public supply. The shafting is divided in the centre by a claw clutch so that one half can be driven independently by the motor, or both gas engine and motor may be used conjointly to supply power to any particular set of machines. The larger generator units are belted to the engine-driven half of the shaft and

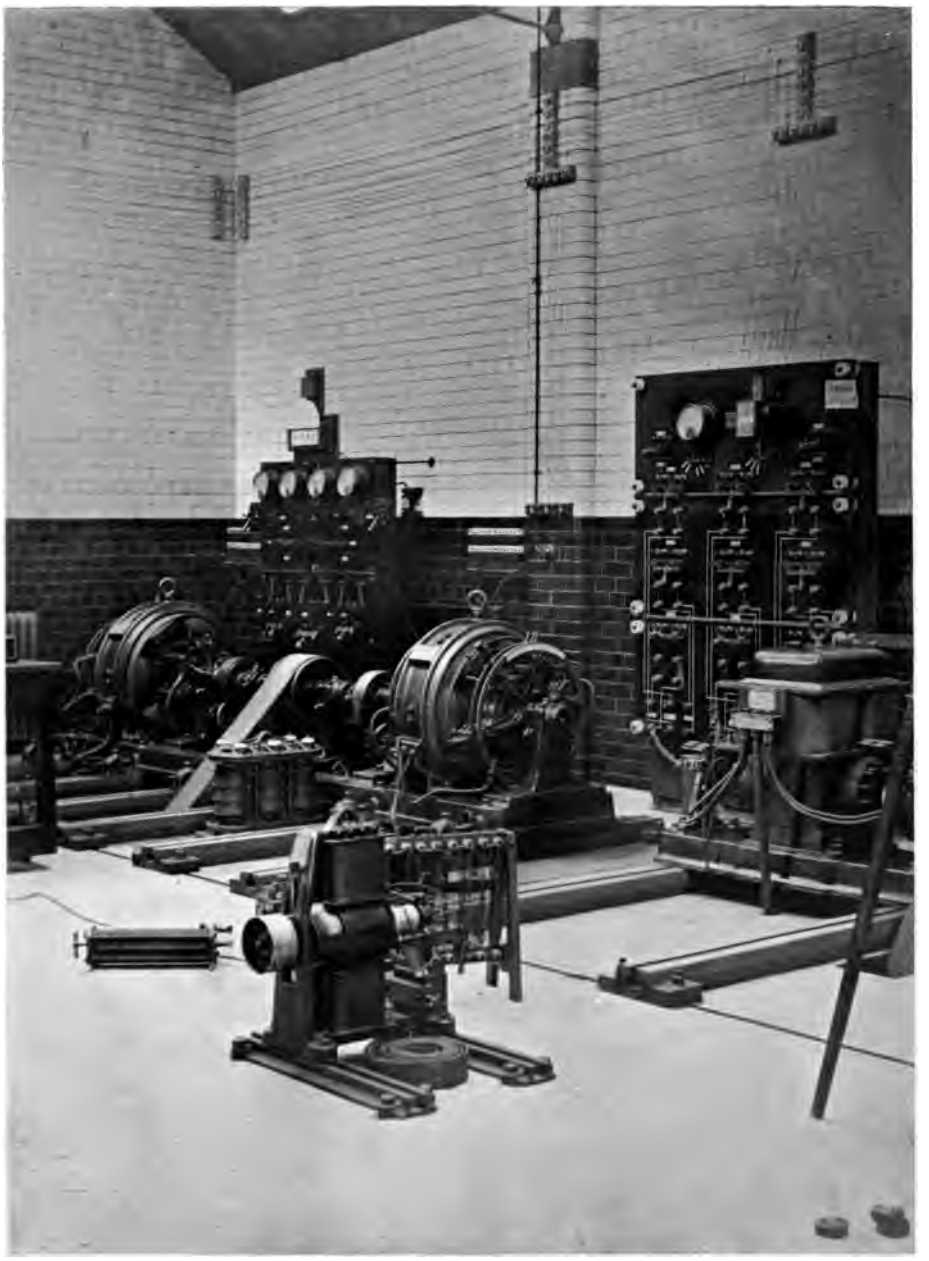

Fig. IV. DYNAMO HOUSE (View I.)

serve as general supply machines for the whole Laboratory, being connected up to a distribution board from which current can be sent to any part of the building. For convenience, arrangements are made whereby the voltage of any of these machines also can be regulated from the Electro-Chemical Laboratory.

Amongst the larger generator units are a pair of similar direct-current shunt machines, each of 18 K.W. output, specially mounted on a combined bed-plate and coupled by friction clutches. These machines are also fitted with slip-rings, enabling them to be used at will as 3-phase generators, synchronous motors, or rotary convertors, so that, in addition to forming the main source of supply of high-voltage direct current for experimental work—as well as for cell charging and lighting, in the event of the public supply failing—they constitute a valuable set on which "Hopkinson" and a great variety of other tests can be carried out.

A supply of low-voltage current for the Electro-Chemical Laboratory is likewise provided for in this room by a 15 K.W. "Castle" dynamo of the double-commutator type, capable of delivering 500 amperes at 30 volts or 1000 amperes at 15 volts, according as the armature halves are in series or parallel.

Mention should also be made of a pair of machines specially built for educational work, and presented by Messrs. Mather and Platt, Ltd. One of these is an 18 K.W. single-phase alternator with a rotating armature, the sections of which can be grouped in different ways so as to vary the current output over a wide range. The other is a 12 K.W. rotating-field polyphase alternator, having an armature ring-wound with six independent phases, which are connected to six separate pairs of terminals, thus permitting a large number of different combinations to be formed, and the machine to be used as a single- two- or three-phaser.

Of special interest, too, are a pair of similar single-phase Wilde machines, representing one of the earliest types of commercially successful alternator. These were presented to the Laboratories by Dr. Henry Wilde, F.R.S. for the purpose of illustrating the property of synchronous running, originally discovered by him.

The smaller generator units—used almost exclusively for testing work—are belted to the motor-driven half of the shaft for the sake of better speed control, whilst the motor units, also small machines mostly intended to be driven from storage cells, are mounted, each on a separate brickwork pillar, at a convenient height from the floor, and fitted with various types of brakes.

Besides the foregoing plant, the Dynamo House is liberally supplied with needful accessory apparatus in the way of single and polyphase transformers; resistances for regulating and power absorption purposes; and measuring instruments, fixed and portable.

A room in the basement in the same wing as the Dynamo House makes a convenient Photometric Gallery. A nucleus of the equipment of this has already been formed, and with the addition of a few of the later modern appliances, photometric work of any kind on arc and incandescent lamps will be capable of being dealt with.

Accumulator Room.

In order to shorten heavy-current connections, this room is conveniently situated in close proximity to the Dynamo House, the Electro-Chemical Laboratory, and the Standardizing Room, where the largest current demand from the cells occurs. It contains two separate batteries, one of 34 cells, presented by the Chloride Electric Storage Co., and another,

Fig. V. DYNAMO HOUSE (View II).

also of 34 cells, presented by the Tudor Accumulator Co. These batteries have capacities of 300 and 135 ampere-hours respectively, corresponding to a maximum discharge rate of 100 amperes. With the exception of 4 cells of each type, which are chiefly used for potentiometer work and are connected by separate leads running direct to the Electrical Laboratories, the batteries are connected at various points to the main distribution switchboard in the neighbouring Standardizing Room.

The remaining rooms devoted to Electrical Engineering are on the ground floor of the main block. They comprise a Standardizing Room, an Electrical and Magnetic Testing Laboratory, an Alternating Current Laboratory, and an additional room which at present is being fitted up as a Drawing Room.

It is hoped at some future date, to provide Laboratories for High Tension Transmission and Traction—both subjects of rapidly increasing importance, for the proper teaching of which no adequate laboratory provision has yet been made in this country.

Standardizing Room.

This room has not yet been fully equipped, but it is proposed to instal the necessary appliances, standards, and instruments for the accurate calibration of direct and alternating current ammeters, voltmeters, and wattmeters; for high-tension testing ; and for standardizing work generally. It also serves the subsidiary purpose of a switchboard room and contains a Main Distribution Board, an Auxiliary Heavy-Current Board, and a Battery Charging Board.

The main Distribution Board (seen on the left hand side of Fig. VI.) consists of a set of 60 vertical 'bus bars, mounted

on the front of white marble panels and connected with 30 separate circuits, supplying the various rooms throughout the Laboratory. Horizontal 'bus bars at the back of the panels, connect through switches and fuses to various points in the battery of accumulators. By inserting plugs, connecting the vertical and horizontal 'bus bars, any desired number of cells up to 60 can be put on to any circuit, and thus practically any voltage up to 120 can be obtained. Finally, two horizontal 'bus bars connect through cables to the Dynamo House and enable direct or alternating current from the dynamos to be supplied to any circuit.

Experimental current is distributed from this plug board to the various rooms in the Laboratory by means of bare copper leads. These are mounted on porcelain insulators fixed to the walls, and pass through the walls from room to room by way of channelled bricks specially provided near the ceiling.

The Main Board is designed for use with currents ranging up to 50 amperes only, but by help of the Heavy Current Board, still larger currents—up to 300 amperes from the Dynamo House and up to 200 amperes from the cells in parallel—can be sent through special cables to the main Lecture Room, as also to several rooms in the Laboratory where such large currents are required.

The Battery Charging Board (shown on the extreme right of Fig. VI) is arranged to allow the two batteries to be charged separately or in parallel, either from the public supply mains or from the Dynamo House; it also permits either battery to be charged in sections of 5 cells at a time.

Electrical and Magnetic Testing Laboratory.

In this room apparatus is installed for the purpose of giving students a working knowledge of the testing of mag-

Fig. VI. MAIN DISTRIBUTION AND AUXILIARY SWITCH BOARDS.

netic materials and commercial measuring instruments, preparatory to their passing on to the testing of direct-current machinery in the Dynamo House. It is furnished with a number of galvanometers of different kinds, ballistic and aperiodic; a specially sensitive high-resistance galvanometer for accurate insulation tests, as well as portable commercial insulation-testing sets; the latest types of instruments for permeability and hysteresis testing; potentiometer; resistance and electro-motive force standards; Kelvin double bridge and other resistance-testing sets; Kelvin balance and a variety of direct-current meters; etc.

Alternating Current Laboratory.

Similarly this equipment is intended to provide introductory work on alternating current measurements preparatory to the testing of alternating current plant. In addition to a large stock of alternating current measuring instruments, Duddell oscillograph, secohmmeter, capacity and inductance standards, etc., the room contains a small motor-generator as a local supply of single-phase current of variable frequency, but single-phase as well as 2-phase and 3-phase currents of fixed frequency from the Dynamo House are also available.

From this brief account it will be seen that the large number of rooms at disposal has made it possible to fit up—or to contemplate the fitting up—of a number of specialized laboratories, each with an equipment of its own. To carry out such a scheme is a process requiring time and funds, but with a reasonable allowance of both it should be possible to build up an Electrical Engineering Laboratory affording facilities for educational and research work of the highest kind.

ELECTRO-CHEMICAL LABORATORY.

The somewhat new departure of including a laboratory for Electro-Chemistry in the Physical Institute is due to the recognition by Dr. Schuster of the rapid development which was in progress in the application of electricity to practical chemical operations.

The importance of providing equipment for teaching this subject was also urged by Mr. Ivan Levinstein, to whose liberality the laboratory is largely indebted for its equipment.

By working in conjunction with the Electrical Engineering Laboratories the equipment for Electro-Chemistry could be economically provided on a much more extensive scale than would be at all possible were the laboratory fitted up as an annex to the Chemical Laboratories.

On the other hand, the fact that this subject must be treated primarily in its application to pure chemistry has never been lost sight of. The success of the laboratory largely depends upon the interest taken in it by the Professors of Chemistry, and the increasing number of chemical students who specialise in this branch of work.

In 1900, Dr. R. S. Hutton was appointed Demonstrator and Lecturer in Electro-Chemistry and has since then had charge of this subject.

The main laboratory is a lofty, well lit and ventilated room, 36 ft. × 38 ft., equipped with the necessary working benches, but with considerable free space around the walls for the erection of temporary experimental plant.

In addition to providing instruction for advanced Chemical students in physico-chemical measurements and in the preparation of chemical substances by electrolysis, ample equipment is made for research work.

Of special importance is the installation of plant for electric furnace operations, which is being steadily extended.

Fig. VII. ELECTRO-CHEMICAL LABORATORY.

A large part of this equipment has been fully described elsewhere‡ so that it is unnecessary here to enter into detail.

The power available for furnace work amounts to some 30 K.W. and the electro-chemical laboratory being placed in close proximity to the Dynamo House, the large currents necessary for some of the furnace operations are easily transmitted.

Both continuous and alternating current are available at voltages varying through a very wide range. For experimental work requiring a high tension discharge, such as is used for instance in the study of gaseous reactions, a 2½ K.W. transformer, giving up to 25,000 volts has been presented by Mr. Arthur McDougal. On the other hand, for the carbon tube furnaces* which are now extensively employed on account of the ease with which they permit of regulation of temperature, currents of 1000 amperes at 15 volts can be obtained

In the development of the electric furnace equipment, Mr. J. E. Petavel has rendered valuable service in designing many of the special types of apparatus required. He has, moreover, applied his experience with high pressure gases to the construction of an electric furnace working under pressures ranging up to 200 Atmospheres. With this apparatus, Mr. Petavel and Dr. Hutton have been engaged during the last few years in an extensive investigation of electric furnace reactions.

Of other work carried out in this laboratory, mention might be made of the electric fusion of quartz. The methods worked out here proved to be sufficiently promising to encourage their application and development on a technical scale, and the problem of making large vessels of quartz glass in the electric furnace is now to a large extent solved.

‡Hutton and Petavel, Journ. Instit. Electr. Engineers, 1903, Vol. 32, p.p. 222-247.
*Hutton and Patterson, Trans. of the Faraday Soc., 1905, Vol. 1, p.p. 187-196.

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*Hutton and Patterson, Trans. of the Faraday Soc., 1905, Vol. 1, p.p. 187-196.

THE PHYSICAL COLLOQUIUM.

At a meeting held in the Lecture room of the old Physical Laboratories, on June 8th, 1894, the following resolution was passed :—

"That a Physical Colloquium be formed, which shall have for its object the encouragement of research and the acquisition of knowledge of recent advances in Physics and allied subjects."

The inauguration of this society was very largely due to the efforts of Dr. Albert Griffiths, who was Demonstrator at the time, the project receiving the firm support of Professor Arthur Schuster.

In this way the Physical Colloquium was started, and has continued to hold its meetings fortnightly, on Friday afternoons, at 4 p.m., throughout the Michaelmas and Lent Terms.

The objects of the Colloquium are rather different to those of the Union Societies of the University, and there is little doubt that, on account of its educational character, much has been gained by a close association with the teaching staff.

One reason for the continued success and popularity of the Colloquium has been the informal character of its meetings. For this, the kindness of Mrs. Arthur Schuster in acting as hostess at practically every meeting, and the interest she has always taken in its welfare, has been mainly responsible.

For the first few years after its inauguration, there were not sufficient men carrying on research work in the laboratories to provide a constant supply of original papers. But since the Physical Department took up its home in the new building, the system of dividing the proceedings into two parts has been generally adhered to, the first consisting of an account of a contributor's own original work, the second of a more or less detailed abstract of some

recently published paper.

This latter function is by no means unimportant, the practice which the students obtain in preparing and delivering short addresses serves as a useful preparation for their future work in the teaching or other professions.

The Colloquium has also discharged other important duties. Whenever it has been necessary for the Physics Department to move in any matter of general interest, the members and officials of the Colloquium have always acted for the whole body of students.

The interesting meeting at which Professors Becquerel, Nernst, Voigt and the late Sir George Gabriel Stokes addressed the members of the Physics Department, on March 13th, 1902, on the occasion of the Jubilee Celebrations of the Owens College, was organised in this way.

Another memorable occasion was the visit of Lord and Lady Kelvin, on November 11th, 1902.

One of the most important tasks undertaken by the Colloquium each year, is the arranging of the Physical Laboratories for an exhibit on the occasion of the Union Soirée. The success which has attended these exhibits is recorded in the glowing letters of thanks which have passed from the secretaries of the Union to the secretaries of the Colloquium.

The following is the list of the honorary secretaries since the foundation :—

Year.	Senior Secretary.	Junior Secretary.
1894.	A. Griffiths.	
1895.	A. Griffiths.	
1896.	A. Griffiths.	J. Lustgarten.
1897.	A. Griffiths.	J. Lustgarten.
1898.	H. Morris-Airey.	G. C. Simpson.
1899.	G. C. Simpson.	D. Farrar.
1900.	G. C. Simpson.	A. S. Eddington.

1901.	A. S. Eddington.	T. Wadsworth.
1902.	H. E. Wood.	R. E. Grime.
1903.	R. E. Grime.	S. MacPherson.
1904.	J. R. Beard.	A. F. Core.
1905.	T. Royds.	W. Wilson.

READING ROOM AND DEPARTMENTAL LIBRARY.

The Departmental Library, which was provided in the new laboratories, is steadily growing, and has already justified its existence in the constantly increasing use which is made of it by the students and other members of the department.

In addition to Physical and General Scientific periodicals, several Electrical Engineering papers are available.

It is hoped in time to collect a good reference library, as the provision of standard books on Physics and sets of journals in the laboratory itself is very desirable.

Fairly complete sets of the following journals have been provided, either by purchase, gift, or loan :—*Nature*, *Physikalische Zeitschrift*, *Science Abstracts*, *Astrophysical Journal*, *Zeitschrift für physikalische Chemie*, *Electrician*, *Electrical Review*, *Electrical World*, *etc.*

This library being primarily intended for reference purposes, should as a rule only possess duplicate copies of such books and journals as are contained in the main University Library, and are more frequently required for consultation in connection with the practical work carried out in the laboratories.

MUSEUM FOR APPARATUS OF HISTORICAL INTEREST.

The most valuable collection consists of a number of pieces of apparatus constructed by James Prescott Joule and presented by his son, Mr. B. A. Joule, to the laboratories.

Fig. VIII. MOUNTING FOR SMALL ROWLAND GRATING.

Most of the instruments have already been fully described by Mr. J. D. Chorlton, who was elected to the first Joule Scholarship of the Royal Society, and worked in the Physical Laboratories. (See *Proc. Roy. Soc.* vol. 59, p.p. 345-359. (1896).

The following are the most important of the exhibits :—

(1) Electric Current Meter used in the determination of the Mechanical Equivalent of Heat from the thermal effects of electric currents.

(2) Electro-magnetic engine constructed in 1837.

(3) Balance sensitive to 1 milligram.

(4) Mercury Air Pump (1874).

(5) Magnetic Dip Circle (1869).

(6) Tangent Galvanometer used in the determination of the Mechanical Equivalent of Heat.

The Laboratory is also in possession of some of the apparatus constructed for the late Dr. John Hopkinson.

LARGE ROWLAND CONCAVE GRATING.

Probably the most important of the special apparatus for research which the laboratory possesses, is the large Rowland Concave Grating, which is mounted in a room on the second floor. The grating, which was specially selected for Professor Schuster by the late Professor Henry Rowland, on account of its high quality, is ruled with 14,438 lines to the inch over a length of six inches, and has a radius of curvature of 21 ft. 6 in.

The construction of the mounting was carried out at the works of Sir Howard Grubb. While the general scheme of Rowland's original mounting has been adhered to, important improvements of detail have been introduced by Dr. Schuster. As in Rowland's arrangement, the grating and the camera are fixed to carriages which move easily on two heavy beams. One beam is capable of adjustment, so as to be

placed accurately at right angles to the other. The carriages are connected by a cross-beam, whose length may be adjusted so that the centre of the plate held in the camera is at the centre of curvature of the concave surface. The slit is placed at the point of intersection of the two beams along which the carriages run. As the camera is moved away from the slit the grating moves towards it, and with this arrangement, as Rowland has shown, the different portions of the spectrum are always in focus in the camera in whatever position it may be situated along the beam.

There are considerable difficulties to be overcome in effecting the adjustments, and the whole apparatus has been designed to make any one of the necessary operations, as far as possible, independent of the others.

The two massive beams span the room several feet above the floor—the one that carries the grating is close to the inside wall, and the other is at right angles to it and about ten feet from the western wall. The former is a hollow rectangular girder of cast-iron 6½ inches high by 8 inches wide and 20 feet long. Its upper surface has been machined, so that the edges form two rails, one ∧ shaped and the other flat. Levelling screws passing upwards, through brackets fixed to the wall, support it and allow the ends to be raised or lowered and the whole beam to be turned about an axis parallel to its length.

The camera beam is a similar but heavier girder having a depth of 18 inches, a width of 8 inches, and a length of 23 feet. Its ends rest on cradles standing in niches in the wall ; each cradle is supported on two adjusting screws which allow the same adjustments to be made as in the case of the grating beam. By means of two strong screws with "tommy-holes" passing through the sides of the cradle, this beam can, in spite of its weight, be easily moved through a small angle and adjusted perpendicular to

the beam carrying the grating.

The cross beam is of circular section, and consists of two steel tubes, one of which telescopes for a portion of its length into the other, to afford a means of adjusting the distance between the camera and the grating. The ends of these tubes are brazed on to lugs, shaped to form horizontal pieces, through whose extremities pass vertical set screws with rounded ends which fit into suitable sockets on the plate with which the grating or camera turns. These set-screws are turned until they all rest evenly in their holes and lock nuts then hold them firmly in this position. The grating and camera are thus constrained to turn as the latter is moved along the beam, and the arrangement, which is due to Sir Howard Grubb, possesses the great advantage of obviating the difficulty, usually encountered, of brazing on the two lugs exactly parallel to one another.

The carriages on which the grating and camera are placed have each three wheels, two are grooved to run on the Λ rail of the beam and are about 18 inches apart, while the third runs on the other rail, which has been planed flat. The three support a triangular casting through whose centre passes the pivot about which the camera or grating turns. Each carriage is stable on its beam without requiring any constraint from the cross-beam. This, combined with the novel construction of the ends of the latter, ensures a freedom from tilting of the grating, and entirely obviates any change of focus due to the sagging or bending of the cross-beam. This constitutes one of the most valuable features of the mounting.

The grating itself is fitted into an open frame, against which it is gently held by light springs, the whole being mounted on a base provided with three levelling screws, which permit of its being rotated slightly about the normal at its centre and about a perpendicular horizontal axis, and

also allow of an adjustment of its height. The base can turn about a central pivot, and a small flange, held between two screws fixed to the plate on which the cross-beam rests, permits a fine adjustment about a vertical axis.

As a slit, capable of vertical and horizontal as well as of a rotatory motion in its own plane, was required, one was specially designed for this instrument. It possesses this additional property, that the knife-edges move through equal distances as the width of the slit is altered, so that the position of its centre remains the same.

The camera-box presents no unusual features save that it can rotate about an axis passing through the centre of the plate, whose orientation can then be adjusted with some accuracy by means of a set-screw. The plate is bent into the arc of a circle by pressing it against stops in the dark slide, and its dimensions usually are 20 inches by 2½ inches.

The camera shutter, which originally was attached to the camera, according to Professor Rowland's instructions, has recently been modified by Mr. Duffield, so as to be separately supported. Spectra can now be taken without fear of any shift due to the operation of the shutter.

The whole of the mounting is supported at such a level above the floor that it does not interfere with the floor space, which is therefore available for other purposes. At one end of the room a large platform has been erected so that the camera can be easily manipulated, and the source of light placed in position and operated during the experiment.

Behind this platform are apertures in the wall through which sunlight can enter after reflexion from a heliostat. This can be placed on one of the ledges projecting from the outside wall, access to which is afforded by a balcony.

A ventilating chimney immediately over the source of light, usually an electric arc or spark, prevents obnoxious fumes from filling the room and injurious gases from reach-

ing the grating surface. In addition a screen of black cloth completely encloses this portion of the room and prevents stray light from affecting the plate. A hole in this screen permits the light to pass from the slit to the grating.

The room can be very perfectly darkened by means of blinds, and a double door permits access to or egress from it during the course of an experiment.

The electrical equipment of the platform consists of leads from the Corporation mains, from the Storage Batteries, and from the Dynamo House, thus giving a wide range in the choice of voltage of both continuous and alternating current.

Echelon Grating Spectroscope.

The Grating Room also contains an Echelon Spectroscope, constructed by Messrs. Adam Hilger, Ltd.

This consists of 33 plates, and has a resolving power for the Na line equal to that of an ordinary grating of 329,000 lines in the first order spectrum.

The peculiarity of the mounting is that it obviates the necessity of an auxiliary spectroscope in front of the Echelon slit, the prism in this case receiving the light after it has been resolved by the grating.

Apparatus for Measuring Spectrum Photographs.

Formerly a small Zeiss Comparator was used for this purpose, but recently, the laboratory has acquired one of Professor H. Kayser's machines, constructed by Max Wolz, of Bonn, which renders the process of measuring up the photographs much less tedious.

The chief novelty of this instrument consists in the fact that each adjustment, instead of being read on the scale or micrometer, is registered by a printing recorder on a tape

by the simple depression of a button. It is consequently unnecessary to remove the eye from the microscope while taking a measurement. Four other buttons enable notes to be made at the same time of the intensity, definition, or other characteristic of any particular line.

SUPPLEMENTARY PROVISION FOR SPECTROSCOPICAL RESEARCH.

In the basement a second laboratory has been reserved for spectroscopical work. In addition to a large Quartz Spectrograph by Fuess, it contains a Rowland Concave Grating of 1 metre radius, with 15,000 lines to the inch on a ruled surface of 3½ inches.

The compact and convenient form of mounting shown in Fig. VIII, was constructed according to Professor Schuster's design by the Cambridge Scientific Instrument Company, and has already been described.*

Amongst other apparatus for spectroscopical research, installed in this room, the following may be mentioned:—

(1) Large Wimshurst Machine. This is a motor-driven 12 Plate Machine constructed by Mr. C. H. Wimshurst, the plates being 2 feet in diameter. It is capable of giving a spark 13 inches long without the use of condensers.

(2) Rochefort Transformer. This is a novel type of induction coil of French manufacture, and gives a spark 20 inches long. The internal construction is different from that of the ordinary coil, the secondary being very short and placed at the middle of the primary. The primary and its iron core extend for some distance on either side of the secondary. The whole is enclosed in a case which is filled with a thick oily insulating material of special composition. The mercury break, which is on a separate mount-

* C. de Watteville, Phil. Trans., vol. 204A., pp. 143-144.

Photo. by Dr. O. V. Darbishire.

Fig. IX. WHITWORTH METEOROLOGICAL OBSERVATORY

ing, is motor driven, and differs from the ordinary form of Foucault interrupter in that the copper rod which dips into the mercury is pointed, and performs its movements vertically.

The condenser is also contained in a separate box, and its capacity can be varied according to the intensity of the current sent through the primary.

The coil will give the full length of spark (20 inches) with a current of 5 amperes at 12 volts.

(3) Rotating disc machine as used by Professor Schuster and Dr. Hemsalech for photographing the spark spectrum of different metals.

(4) Modified form of Gouy Salt Spraying Apparatus, as used by Monsieur C. de Watteville in his investigation of the flame spectra of the metals, and more recently by Miss C. Radford.

METEOROLOGY.

The meteorological activity of the Physical Department dates back to the year 1892, when the Whitworth Trustees handed over to the Owens College the Observatory which they had erected and equipped in Whitworth Park—about ten minutes' walk from the University. The generosity of the Whitworth Trustees was also responsible for the permanent endowment of this observatory in 1897.

From the year 1892 regular observations of the barometric pressure, temperature, humidity, wind direction, wind velocity, and amount of sunshine have been taken at 9 a.m. and 9 p.m. daily. Records are supplied to the "Manchester Guardian" and the "Manchester Courier" daily, and weekly summaries are published in the "Manchester City News."

In January, 1901, the Observatory became a second class station attached to the London Meteorological Office, to which the observations are forwarded, to be used in the general work of the Office.

Last year, the University, at the request of Dr. Schuster, decided to extend the meteorological work by establishing a separate department in which the scientific study of the subject, as a special branch of physics, could be pursued.

With this end in view, Mr. G. C. Simpson was appointed University Lecturer in Meteorology and the Observatory was given into his charge. For several years a portion of the endowment fund had been allowed to accumulate, and with this it was decided to make the equipment of the Observatory more effective and complete, especially by the provision of self-registering instruments of modern type.

A sum of nearly £200 was spent, and as a consequence the Observatory is now one of the best equipped in the country. The instruments in daily use are the following :—

Read at 9 a.m. and 9 p.m.	Barometer.
	Dry Bulb Thermometer.
	Wet Bulb ,,
	Maximum ,,
	Minimum ,,
	Black Bulb ,,
	Grass ,,
	Rain Gauge.
Self recording instruments.	Barograph.
	Robinson Anemometer.
	Dines-Baxendell Pressure Tube Anemometer and Anemograph.
	Sunshine Recorder.

The daily observations are at present taken by Messrs. F. Marquis and J. West, students of the University.

The study of Meteorology at the University has had a good beginning, the new courses of lectures being well attended. Several Honours students are taking Meteorology as the special subject to be presented for their degree, and some have

undertaken researches bearing on Meteorology. It is hoped that original research in this subject will in future form a constant part of the work of the physics department.

Owing to the lack of special information it is impossible to undertake forecast work; but each day a map of the weather of North-West Europe is drawn from observations taken the previous evening at 6 p.m. and specially forwarded from the Meteorological Office, London. The maps are placed on a notice board in the entrance hall of the Laboratory, together with the observations taken at the Observatory itself. Considerable interest in these maps has been evinced by the students themselves, and by visitors to the Laboratories.

The formation of the department of Meteorology has made it possible for the University to take part in the work of the International Committee for the investigation of the upper atmosphere. With this object in view, a site has been chosen on the Derbyshire moors where a station has been erected from which periodical kite ascents can be made. The station is fitted with a small steam engine for paying out and winding in the steel wire to which the kites are attached, and all the necessary appliances for the work are being installed.

The use of kites for meteorological purposes has proved of great value during the last few years; much work in this direction having been done in Germany, and in this country by Mr. Dines in the neighbourhood of London. It may well be expected that with such an excellent situation as that found for the new station, this successful work will be continued in connection with the Manchester University.

ATMOSPHERIC ELECTRICITY.

As a result of the early work of Professor Schuster on this subject, and the interest which he has always taken in the

experimental investigation of such problems, the laboratory is now in possession of extensive equipment for this work. Mr. G. C. Simpson, whose sojourn in Lapland, during his tenure of the 1851 Exhibition Scholarship, was largely devoted to research on atmospheric electricity, has now set up the following apparatus which is in constant use.

(1) Benndorf Self-registering Electrometer for measuring the atmospheric potential gradient.

(2) Ebert Apparatus for measuring the ionisation of the air. The air being drawn by a small fan through a charged cylindrical condenser, the amount of discharge in a given time being noted.

(3) Dissipation Apparatus of Elster and Geitel, in which the rate is determined at which electrically charged bodies lose their charge when exposed to the air.

(4) Complete set of apparatus for measuring the amount of Radio-active Emanation in the atmosphere.

RADIO-ACTIVITY.

The discovery of the radio-active elements has opened up an entirely new field for scientific enquiry, and so great has been the influence of the investigations in this subject upon physical theories, during the last few years, that no physical laboratory could be considered complete without the means for carrying on research in this branch of science. The department now possesses between 60 and 70 milligrams of the most active preparation of radium bromide. The greater part of this radium was purchased by Professor Schuster for the Laboratory from the proceeds of a course of four lectures on "Rays and Radio-Activity" given in October and November, 1903. With this large provision of material, experimental work is much facilitated.

Of work on this subject carried out in the Laboratories,

we may mention the investigations of Mr. W. Makower, who, during his tenure of the John Harling Fellowship, 1903-1906, has devoted his time to research on several problems in radio-activity.

THERMAL CONDUCTIVITIES.

RESEARCHES OF DR. C. H. LEES.

No record, however modest its aim, would be complete without reference to the extensive work of Dr. Lees on heat conductivity, which has been conducted here. His long association with the department is about to be severed by his appointment to the Professorship of Physics in the East London College.

Besides devising methods for measuring thermal conductivities of the most varied materials, he has recently been investigating the effects of temperature and pressure upon these constants.

The methods used in the early work on crystals and other comparatively poor conductors of heat, published in the *Phil. Trans.* for 1891, have been modified in the more recent work. The heat, which is conducted through the material to be tested, is now generated and measured electrically. Similarly he has substituted the platinum resistance for the thermo-electric method of measuring temperature. The recent determination of the heat conductivities of some electrically insulating materials down to the temperature of liquid air, will be found in the *Phil. Trans.* for 1905, and Dr. Lees is now engaged in determining the thermal conductivities of metals and alloys down to these low temperatures.

SOAP FILM RESEARCH.

Amongst the other apparatus at present in use may be mentioned the instruments employed by Mr. H. Stansfield

for examining soap films and measuring their thickness.

Mr. Stansfield has devoted some years principally to the study of "black films," which are films so extremely thin that they can scarcely reflect any light. He commenced this work with Professor Rücker at the Royal College of Science. On taking up the subject again in Manchester, a new departure was made by examining these black films with a microscope, and it was found that the abrupt change from the thicker to the thinner kind of black film, which was observed by Newton, is only the last of a series of similar changes which take place during the process of thinning.

By means of a camera, specially constructed for the purpose, photographs have been obtained, showing the whole series of changes. These photographs have recently been published in the Proceedings of the Royal Society.

LOW TEMPERATURE RESEARCH.

Thanks to the generosity of Sir Henry Roscoe, the laboratory is provided with a complete plant for the production of liquid air. The liquefier is of the Hampson Type, constructed by the Brin's Oxygen Company, Ltd., of London. A Whitehead Compressor, driven by a 7 H.P. Crompton motor, supplies the air at a pressure of 175 Atmospheres.

With this plant, Liquid Air can be produced at the rate of about a litre per hour.

The distinguishing feature of this type of apparatus is the very short time necessary for starting the liquefaction. In about twenty minutes after the motor is switched on, the liquid already begins to form, and from this time onwards, the rate of production is steadily maintained.

During the last few years the equipment has been found of great value for physical investigations at low temperatures, and has worked with remarkably few complications.

Automatic Mercury Vacuum Pump.

The liquid air room, also contains an Automatic Mercury Pump, as designed by the late Professor G. W. A. Kahlbaum, and constructed by Kramer of Freiberg im Breisgau. It is capable of working continuously for several days with but little attention, and gives an extremely high vacuum.

APPARATUS FOR RESEARCHES UNDER HIGH GASEOUS PRESSURES.

During the last five years a considerable amount of work has been carried out bearing on the effect of high pressures on the physical and chemical properties of matter. A description of the laboratory equipment would, therefore, not be complete without some brief reference to the apparatus provided for this work.

A gasometer and compressing pump have been installed in a room adjoining the electro-chemical laboratory. The various gases are manufactured and compressed at the rate of about one litre per second ; the maximum working pressure being 200 Atmospheres (about 3000 lbs per square inch).

Nitrogen, carbon monoxide, and ethylene are generated in specially constructed furnaces placed in the electro-chemical laboratory, while hydrogen is prepared in the accumulator room. Both places are connected to the gasometer by a permanent system of pipes. Provision is also made for compressing coal gas, which may be drawn direct from the mains. This plant has been fully described in the Journal of the Society of Chemical Industry, February 15th, 1904. It forms a somewhat unique equipment for a Physical Laboratory and has already proved of great value for many investigations in which pure gases are required under high pressure.

In the pump room is placed the apparatus used by Mr. Petavel for his researches on Explosive Pressures.

Two explosion chambers have been constructed, the one is spherical, the other cylindrical in shape, both are exceptionally strong, and pressures of 30,000 lbs. per square inch have frequently been attained during the course of the work. We cannot enter here into a detailed description of the somewhat elaborate mechanism which serves to regulate the composition and initial pressure of the gaseous mixtures. Suffice it to say that after these factors have been adjusted the rate at which the pressure in the enclosure rises and falls, before and after the explosion, is photographically recorded on a rapidly revolving chronograph cylinder. The records give all the necessary data with regard to the rate of combustion, maximum pressure, specific heat, etc., of the mixture under observation.

In an annex to the boiler house, a second pump intended for low pressures (60 lbs. per square inch) has been erected. This pump is direct driven by a steam engine, and communicates with a system of pipes which distribute compressed air over the entire building. The air thus supplied is used for the various blast furnaces, blow pipes, etc.

In connection with the high pressure work referred to above, an interesting piece of apparatus has recently been constructed at the University Engineering Works, to the design of Mr. Petavel. This consists of a combined force pump and ram, giving respectively pressures up to 15,000 and 37,000 lbs. per square inch. A special arrangement of valves enables the highest pressures to be maintained for an indefinite period of time.

The pump has been specially constructed for a research, dealing with the properties of radium when under high pressure. It will, however, be of considerable general value for testing hydraulically the various apparatus in use in the laboratory.

ii. Professor Arthur Schuster.

BIOGRAPHICAL AND BIBLIOGRAPHICAL NOTES.

ii. Professor Arthur Schuster.

Biographical and Bibliographical Notes.

Born, September 12th, 1851, at Frankfort-on-Main. Educated, first at a private school, then at the Gymnasium at Frankfort, during which time he received his first instruction in Mathematics and Physics from Dr. Harald Schütz (afterwards Professor of Mathematics at the Frankfort Gynmasium), who lived with the family as private tutor. At the age of 17 he went to Geneva where, during two years, he attended lectures at the University under Marignac in Chemistry, Soret in Physics, and Plantamour in Astronomy.

1870. (Summer). Came to England, entered his father's business and during the winter session attended evening classes at the Owens College under Sir Henry Roscoe.

October, 1871. Entered as a day student at Owens College, working in the Physical Laboratory, which Balfour Stewart was then beginning to organise. His first spectroscopical research was conducted during that year.†

1872-1873. Student at Heidelberg under Kirchhoff.

1873. (February 25th). Graduated at Heidelberg as Ph.D.

1873. (October). Demonstrator (Honorary) in the Physical Laboratory, Owens College, this being the first session in which the College work was carried on in the present building in Oxford Street.

† "On the Spectrum of Nitrogen." *Proc. Roy. Soc.*, vol. 20, p.p. 484-487. (1872).

1874. (Summer vacation). Research at Göttingen under Wilhelm Weber and Riecke.

1874. (October). Research in Helmholtz's Laboratory in Berlin, until Christmas. Return to Berlin after the new year had to be abandoned owing to his appointment as :—

1875. Chief of British Eclipse Expedition to Siam (April 1875). On the return journey spent some time on tour through the Himalayas, walking from Simla to Leh, and returning by way of Cashmir.

1875. (November). Returned to Owens College for a second session as Honorary Demonstrator. Three public lectures given during this session on the Siamese Eclipse and return journey through the Himalayas.

Lectured during the session on Maxwell's Theory of Electricity which had been published two years previously. This course of lectures was attended by Messrs. J. J. Thomson (2nd Wrangler 1880, Cavendish Professor of Physics in the University of Cambridge); A. E. Steinthal (3rd Wrangler 1881, and late Fellow of Trinity College, Cambridge); and J. P. Whitney (24th Wrangler 1881).

His experiments proving that the motion of the radiometer is due to internal forces and not to a direct action of light, were also conducted during this session.

1876. (October), to 1881. (Except for intervals). At the Cavendish Laboratory, Cambridge, working first with Clerk Maxwell, and for the latter part of the time with Lord Rayleigh.*

1878. (Summer vacation). Journey to Colorado for observation of total solar eclipse.

1879. Elected a Fellow of the Royal Society.

1881. (June 17th). Appointed Professor of Applied Mathematics in the Owens College.

* Lord Rayleigh and Arthur Schuster. "On the Determination of the Ohm in Absolute Measure." *Proc. Roy. Soc.*, vol. 32, p.p. 104-141. (1881).

1882. British Eclipse Expedition to Egypt, where, on plates prepared by Sir Wm. Abney, he first photographed the Spectrum of the Solar Corona.

1884. His first Bakerian Lecture of the Royal Society: "The Discharge of Electricity through Gases."

1885. Elected Honorary Member of the Apalachian Club, Boston, Mass.

1885-1887. Member of the Council of the Royal Society.

1885-1888. Honorary Secretary of the Manchester Literary and Philosophical Society.

1886. British Eclipse Expedition to the West Indies.

1887. (September). Married the eldest daughter of George Loveday, Esq., of Wardington, Oxon.

Since 1888. After the death of Professor Balfour Stewart appointed Langworthy Professor of Physics in the Owens College, now the University of Manchester.

Since 1888. Governor of Giggleswick School on nomination of Owens College and Manchester University.

1890. Elected an Associate of the Owens College.

1890. His second Bakerian Lecture of the Royal Society: "The Discharge of Electricity through Gases."

1891. Elected Honorary Member of the Cambridge Philosophical Society.

1892. President of Section A. (Mathematics and Physics) British Association Meeting at Edinburgh.

1892-1894. President of the Manchester Literary and Philosophical Society.

1893. Royal Medallist of the Royal Society.

1896. Elected member of the Athenæum Club under Rule II, allowing the Committee to elect nine persons every year on the ground of distinction in Science or Letters.

1897. Visited the Yerkes Observatory at the invitation of the Chicago University on the occasion of the opening of the Observatory.

1897-1902. Representative of the Owens College on the Technical Instruction Committee of the Manchester Corporation.

1898. (Easter). On behalf of the Royal Society visited the "Kartel" Meeting of German Academies at Göttingen, to report on its working.

1898-1899. Member of the Council of the Royal Society.

1899-1904. Representative of the Owens College and Manchester University on the Technical Instruction Committee, and later on the Education Committee, of the County Borough of Bolton.

1899. (Oct.) Delegate of the Royal Society at the preliminary meeting, held at Wiesbaden, for the organisation of the International Association of Academies.

1899-1902. Member of Executive Committee of National Physical Laboratory, during the period of its inauguration and first organisation.

1900. (June). Opening of the New Physical Laboratories of the University of Manchester.

1901. Elected Corresponding Member of the Royal Academy of Sciences of Göttingen.

1901. Elected Corresponding Member of the Royal Philosophical Society of Glasgow.

1901. (April). Delegate of the Royal Society at the First General Meeting of the International Association of Academies in Paris.

1902. Chairman of the Sub-section of Astronomy and Cosmical Physics at the British Association meeting at Belfast.

1902. (Dec.). Gave evidence before the Privy Council on behalf of the Owens College, with regard to the Proposed Disruption of the Victoria University.

1903-1905. First Dean of the Faculty of Science, University of Manchester.

Since 1903. Representative of the University on the Manchester Education Committee.

1903. Honorary Member of the Medico-Physical Society of Erlangen.

1904. (May). Delegate of the Royal Society at the Second Meeting of the International Association of Academies in London.

1904. Chairman of Seismological Committee of the International Association of Academies.

1904. Honorary Sc.D. Degree, Cambridge University.

1905. M.Sc. (Manchester University).

1905. Delegate of British Government at Meeting of International Association of Seismology, in Berlin.

1905. On the nomination of the Royal Society appointed by H.M. Treasury member of Meteorological Committee for the management of the Meteorological Office.

1905. (Oct.). Appointed by the Council of the Royal Society to be the Representative of the Royal Society on the Council of the International Association of Academies.

Since 1905. Chairman of Executive Committee of the International Solar Physics Union.

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Lord Rayleigh.	Professor A. R. Forsyth.
Sir Wm. Huggins.	Professor R. T. Glazebrook.
Sir W. de W. Abney.	Professor E. C. Pickering.
Professor T. E. Thorpe.	Professor J. J. Thomson.
Professor Sir James Dewar.	Mr. Henry Wilde.

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Professor Henri Becquerel.	Professor William Jack.
Professor R. Chodat.	Principal Oliver J. Lodge.
Principal G. Carey Foster.	Professor W. Nernst.
Dr. J. W. L. Glaisher.	Professor J. H. Poynting.
Principal E. H. Griffiths.	Professor William Tilden.
Principal W. M. Hicks.	Professor W. Voigt.
Dr. E. W. Hobson.	Professor H. M. Ward.
Professor G. B. Howes.	

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iii. Records of Past Students, Demonstrators, etc., who have been connected with the Physical Laboratories, or have studied Applied Mathematics under Professor Schuster.

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1881-1906.

THOMAS COULBORN ARMITAGE. Born, December 21st, 1871.

1890-1893. Studied in the Honours School of Physics.

1893. B.Sc. (3rd Class Honours in Physics).

1896. M.Sc.

JAMES REGINALD ASHWORTH. Born, July 8th, 1861, at Rochdale.

Since 1885. Honorary Secretary of the Rochdale Literary and Scientific Society.

1891-1893. Studied at the Owens College.

1893. B.Sc.

1893-1894. Research with Professor Arthur Schuster.

1895. Demonstrator in Physical Laboratories.

1897-1900. Honorary Research Fellowship.

Since 1896. Lecturer in Physics, Municipal Technical School, Rochdale.

1899. M.Sc.

Since 1903. Representative of the Manchester University on the Education Committee of Rochdale.

1903. D.Sc.

Author of the following papers whilst connected with the laboratories:—

"Seasonal Variation of the Temperature of Exposed Water

* It has, unfortunately, not been possible to make the list complete, but it is hoped that the names of those who have been at all intimately connected with the Department have been included.

iii. Records of Past Students, Demonstrators, etc., who have been connected with the Physical Laboratories, or have studied Applied Mathematics under Professor Schuster.*

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Contributions to The Review of Science in *The Annual Register*. 1901, 1902, 1903, 1904, 1905.

SAMUEL GREENUP ATKINSON. Born July 12th, 1885, at Caldbeck, Cumberland.

1903-1906. Student in the Honours School of Physics.

GEORGE HERBERT BAILEY. Born May 17th, 1852, at Barnard Castle.

1875-1879. Head Master of the Grammar School, Bowes, Yorkshire.

1880-1882. Science Master, Tettenhall College, Staffs.

1882-1884. Research Student at the Owens College under Sir Henry Roscoe and Professor Schorlemmer.

1883. Spectroscopical Research in Physical Laboratories.

1884-1885. Study and Research in Laboratory of Professor R. Bunsen at Heidelberg.

1885. Ph.D. Heidelberg and D.Sc. London.

Since 1885. Lecturer in Chemistry in the University of Manchester.

In conjunction with Professor ARTHUR SCHUSTER, author of the following paper on work carried out in the physical laboratories :—

" On the Absorption Spectrum of Didymium Chloride." *Brit. Assoc. Report*, 1883 (Southport). p. 400.

Amongst work of a physical nature carried out elsewhere, the investigation of Manchester Fogs and several spectroscopical researches should be mentioned. (For Bibliography see, P. J. Hartog. *The Owens College*. Manchester : Cornish, 1900).

JOHN MCLEAN BALDWIN. Born, June 23rd, 1883, at Colne. Lancashire.

1901-1904. Studied in the Honours School of Physics.

1904. B.Sc. (3rd Class Honours in Physics).

Since 1904. Physics Master at Tannton's School, Southampton.

HARRY BAMFORD. Born, March 10th, 1866, at Oldham.

1885-1888. Studied at the Owens College.

1888. B.Sc. (1st Class Honours in Engineering).

1888-1893. Assistant Lecturer in Engineering at the Owens College.

1893-1896. Associate Professor of Hydraulics, McGill University, Montreal.

Since 1906. Lecturer on Engineering Drawing and Design at Glasgow University; also Consulting Engineer.

1897. A.M.I.C.E.

1901. M.Sc.

Author of numerous papers on Engineering subjects. Has recently designed a large plant for the extraction of gold by the Cyanide Process for use in South Africa.

LEONARD NOEL BARKER. Born December 25th, 1882, at East Dereham, Norfolk.

1900-1903. Studied in the Honours School of Physics.

1901. Heginbottom Scholarship.

1903. B.Sc. (1st Class Honours in Physics).

Since 1904. Assistant Examiner in H.M. Patent Office, London.

GEORGE W. BARROW. Born, December 3rd, 1864, at Lancaster.

1884-1885. Studied in the Physical Laboratories.

1885. B.Sc. (London).

Hon. Secretary of the Storey Institute, Lancaster, until its transference to the Corporation. Lecturer on Scientific Subjects.

JAMES ROBERT BEARD. Born September 19th, 1885, in Manchester.

1902-1905. Studied in the Honours School of Physics.

1905. B.Sc. (1st Class Honours in Physics).

Since 1905. Junior Assistant to the Newcastle-upon-Tyne Electric Supply Co.

In conjunction with R. S. HUTTON, author of the following paper on work carried out in the laboratories :—

"Notes on Heat Insulation, Particularly with Regard to Materials used in Furnace Construction." *Trans. Faraday, Soc.* vol. 1. p.p. 264-270. (1905); also *Engineering.* vol. 80. p.p. 64-65. (1905).

ROBERT BEATTIE. Born May 13th, 1873, at Fordoun, Kincardineshire, Scotland.

1890. Entered Durham College of Science, Newcastle-on-Tyne, as open exhibitioner.

1891. Awarded Thomas Young Hall Scholarship.

1892. Awarded Charles Mather Scholarship.

1892. B.Sc. (Dunelm) with Honours in Experimental Physics.

1892-1894. Research at Durham College of Science.

1894. Awarded (1851) Exhibition Scholarship.

1894-1896. Research at Durham College of Science, and in the Electrical Engineering Laboratories at University College, London, under Professor Fleming.

1896-1900. Demonstrator in Physics at the Owens College.

1897. M.Sc. (Dunelm).

Since 1900. Lecturer in Electrical Engineering at the Owens College and the Manchester University.

1903. D.Sc. (Dunelm).

Author of several papers in the *Phil. Mag.*, *Electrician*, etc, and of the following publications whilst connected with the laboratories.

"The Wehnelt Interrupter." Letter to *Electrician*. vol. 42. p. 732. (1899).

"The Spark Length of an Induction Coil." *Phil. Mag.* (5). vol. 50. p.p. 139-148. (1900).

"Note on a Possible Source of Error in the Use of a Ballistic Galvanometer." *Phil. Mag.* (5). vol. 50. p.p. 575-579. (1900).

"The Hysteresis of Nickel and Cobalt in a Rotating Magnetic Field." *Phil. Mag.* (6). vol. 1. p.p. 642-647. (1901).

"Note on the Length of the Break-Spark in an Inductive Circuit." *Phil. Mag.* (6). vol. 2. p.p. 653-658. (1901).

"Test Coils for Alternating-Current Wattmeters." *Electrician*. vol. 48. p.p. 818-819. (1902).

"The Normal Saturation of Alternator Fields." *Electrician* vol. 49. p.p. 479-480. (1902).

"An Electric Quantometer." *Electrician*. vol. 50. p.p. 383-385. (1902).

ALBERT HENRY BELL. Born October 4th, 1877, at Dearham, Cumberland.

1899-1902. Studied at the Owens College.

1902. B.Sc.

1902-1903. John Harling Scholar in Physics, and Assist. Demonstrator in the Physical Laboratories.

1903-1904. Demonstrator in Physical Laboratory at the Royal College of Science, London.

1904-1905. Science Master at the Municipal Technical School, Birmingham.

Since 1905. Head of the Physics Department, Science and

Art Institute, Walsall.

Joint Author of "*Notes on Volumetric Analysis*," London: John Murray. 1905.

THOMAS THOMPSON BEST. Born, March 16th, 1867 at Liverpool.

1883-1886. Study at the Owens College, and Spectroscopical Research with Professor Schuster.

1886-1888. Research under Professor Otto Fischer at Erlangen.

1888. Ph.D. (Erlangen).

1888-1889. Assistant Lecturer in the Manchester Technical School.

1889-1891. Chief Chemist to Messrs. J. C. Gamble & Son, St. Helens.

Since 1891. Manager of the Hardshaw Brook Works of The United Alkali Co., St. Helens.

Author of Paper in *Liebig's Annalen* and the following on work carried out in the laboratories.

"On the Delicacy of Spectroscopic Reaction in Gases." *Mem. Manch. Lit. & Phil. Soc.* vol. 26. p.p. 102-108. (1887).

JOHN BRADBURY. Born, December 17th, 1854 at ?

1896-1897. Studied in the Physical Laboratories.

1900-1901. Studied in the Physical Laboratories.

Since 1896. Lecturer on Physics at Oldham Municipal Technical School.

LAWRENCE BRADSHAW. Born, December 28th, 1880, at Newton-le-Willows, Lancashire.

1897-1900. Studied at the Owens College.

1900. B.Sc. (2nd Class Honours in Chemistry).

1900-1903. Research with Professor Dixon in the Chemical Laboratories.

1901-1903. Dalton Scholar

1903. M.Sc.

1903-1905. Research with Professor K. Elbs, at Giessen.
1903-1906. (1851) Exhibition Scholar.
1905. Ph.D. (Giessen).
1905-1906. Research Fellow in the Electro-Chemical Laboratory, University of Manchester.
Joint Author of papers in the *Phil. Trans.*, *Zeitsch. für phys. Chem.* etc.

WILLIAM STANSFIELD BROOKS. Born, May 21st, 1877, at Oldham.
1897-1900. Studied in the Honours School of Physics.
1900. B.Sc. (2nd Class Honours in Physics).
Since 1901. Lecturer on Mechanical and Electrical Engineering at the Norwich Technical Institute.
1903. M.Sc.

CHRISTIAN FREDERICK BUDENBERG. Born, May 2nd, 1864, at Manchester.
1880-1883. Studied at the Owens College.
1883. B.Sc. (2nd Class Honours in Engineering).
1886-1887. Sub-Editor of *Industries*.
Since 1889. Manager and Managing Director of Messrs. Schäffer & Budenberg Ltd., of Manchester, London and Glasgow.

JOHN BENJAMIN BUTLER BURKE, of Ower, Co. Galway. Born, November 4th, 1873, in Manila.
1889. Entered Trinity College, Dublin.
1892. Obtained Mathematical Scholarship. 1st Class Honours in Mathematics and Experimental Science, and
1893. Graduated as Senior Moderator and Gold Medallist.
1897. M.A. (Dublin).
1894-1895. Assistant Lecturer in Physics, Mason College, Birmingham.
1895-1898. Berkeley Fellow at the Owens College.

Since 1899 at Trinity College, Cambridge.

1900. B.A. Research Degree. (Cambridge).

1905. M.A. (Cambridge).

1905-1906. Lectured extensively throughout the United Kingdom.

Author of papers in *Phil. Trans.*, *Phil. Mag.* etc. Articles in Fortnightly, Monthly and University Reviews, and of a book "On the Origin, Physical Basis and Definition of Life." (Chapman and Hall). 1906.

Also, of the following papers whilst connected with the laboratories.

"Experiments on Roentgen Rays." *Electrician*, vol. 37, p. 373. (1896).

"On the Change of Absorption produced by Fluorescence." *Report Brit. Assoc.* 1896. (Liverpool). p. 736; *Proc. Roy. Soc.* vol. 61. p. 485. (1897); *Phil. Trans.* vol. A. 191. p.p. 87-104. (1898).

"Experiments on the Luminosity Produced by Striking Sugar." *Report Brit. Assoc.* 1898. (Bristol). p. 810.

JOHN LEOPOLD CATEAUX. Born, June 3rd, 1873, at Fallowfield.

1890-1892. Studied Electrical Engineering at the Owens College.

1892. Assistant in Testing Department, W. T. Goolden & Co., London.

1893-1896. Assistant Designer. W. H. Allen, Son & Co. Ltd., Bedford.

1896-1899. Chief of Marine Electrical Department. W. H. Allen, Son & Co. Ltd., Bedford.

1899-1902. Assistant Engineer for Traction, Power, and Lighting Department. British Thomson Houston, Co. Ltd., Rugby.

Since 1902. Head of Traction and Lighting Department, British Thomson Houston Co. Ltd., Rugby.

JAMES DEWSBURY CHORLTON. Born, January 13th, 1873, at Manchester.

1891-1894. Studied in the Honours School of Physics.

1894. B.Sc. (1st Class Honours in Physics).

1894. Elected first Joule Scholar of the Royal Society.

1895. Research in the Physical Laboratories.

1895. Entered the Middle Temple.

1898. Called to the Bar, and has since practised in London.

Author of the following papers on work carried out in the laboratories :—

" Report on the Examination of some of the Scientific Instruments Employed by the late Dr. Joule." *Proc. Roy. Soc.* vol. 59. p.p. 345-359. (1896).

Also, in conjunction with Dr. C. H. LEES.

" On a Simple Apparatus for Determining Thermal Conductivities of Cements and other Substances used in the Arts." *Phil. Mag.* (5). vol. 41. p.p. 495-503. (1896).

HAROLD CLARKE. Born, November 22nd, 1881, at Oldham.

1902-1905. Studied in the Honours School of Physics.

1905. B.Sc. (2nd Class Honours in Physics).

Since 1905. Science Master in Fishguard County School.

ARTHUR WILLIAM CROSSLEY. Born, February 25th, 1869, at Accrington, Lancashire.

1887-1890. Studied at the Owens College.

1890. B.Sc. (2nd Class Honours in Chemistry).

1890-1891. Research in Physical Laboratories.

1891-1892. Research with Professor Emil Fischer, in Wuerzburg and Berlin.

1892. Ph.D. Wuerzburg.

1893. M.Sc.

1894. Bishop Berkeley Fellowship, Owens College.

1895. Demonstrator in Chemistry, St. Thomas's Hospital.

1895. Assistant Examiner in Chemistry, London University.
1899. D.Sc.
1900. Lecturer in Chemistry, St. Thomas's Hospital.
Since 1904. Professor of Chemistry, Pharmaceutical Society of Great Britain.
1905. Elected Honorary Secretary of the Chemical Society of London.
Author of papers in the *Journal of the Chemical Society* and *Berichte* since leaving the College, and of the following paper on work carried out in the Physical Laboratories :—
"On the Electrolysis of Silver Nitrate in Vacuo." *Proc. Roy. Soc.* vol. 50. p.p. 344-358. (1892); also in "Studies from the Physical and Chemical Laboratories of the Owens College." vol. 1. p.p. 80-96. (1893).

ERNEST EDWARD DENTITH DAVIES. Born March 4th, 1870, at Ramsey, Isle of Man.
1886-1893. Studied at the Owens College.
1889. B.Sc. (3rd Class Honours in Mathematics).
1890. 3rd Class Honours Physics.
1892. M.Sc.
1893. B.A.
Since 1895. Congregational Minister.

GEORGE FREDERIC DOUGLAS. Born, June 3rd, 1882, at Wellingborough.
1901-1904. Studied in the Honours School of Physics.
1904. B.Sc. (3rd Class Honours in Physics).
Since 1905. Science Master at the Southport Modern School.

PERCY ENFIELD DOWSON. Born, July 24th, 1873, at Gee Cross, near Hyde, Cheshire.
1891-1896. Science Scholar at Trinity College, Oxford, holding Science Exhibition from Rugby School.

1896. B.A. (3rd Class Honours in Chemistry).
1896-1898. Studied in the Physical Laboratories.
1898-1900. Research Student in the Physical Laboratories.
1899. M.A. (Oxford).

WALTER GEOFFREY DUFFIELD. Born, August 12th, 1879, at Gawler, South Australia.
1900. B.Sc. (Adelaide University).
1900-1901. Junior Demonstrator in Physics, Adelaide University.
1901. Angas Engineering Scholarship.
1901-1903. Trinity College, Cambridge. Affiliated Student.
1903. B.A. (Mechanical Science Tripos).
1903-1904. Research Assistant at National Physical Laboratory.
Since 1904. Honorary Research Fellow in Physics, University of Manchester.
Author of paper in *Trans. of the Royal Society of South Australia.*

ARTHUR STANLEY EDDINGTON. Born, December 28th, 1882, at Kendal.
1898-1902. Studied in the Honours School of Physics.
1900. Heginbottom Scholar.
1902. B.Sc. (1st Class Honours in Physics), and University Scholarship.
1902-1905. Trinity College, Cambridge.
1904. Senior Wrangler.
1905. Class I. Div. I. Part II. Mathematical Tripos.
1906. Chief Assistant at Royal Observatory, Greenwich.

WALTER HERBERT EVANS. Born, January 29th, 1883, at Strasburg, Alsace.
1900-1903. Studied at the Owens College.
1903. B.Sc. (2nd Class Honours in Chemistry).

1903-1904. Research with Professor H. B. Dixon, F.R.S.

1904. Research in Electro-Chemical Laboratory.

1904-1905. Studied Electrical Engineering and Advanced Physics.

1905-1906. Technical Chemist.

Author of the following paper on work carried out in the laboratories :—

"On the Electrolytic Preparation of Titanous Sulphate." *Mem. & Proc. Manch. Lit. & Phil. Soc.* vol. 49. No. 2. p.p. 1-3. (1904).

THOMAS EWAN. Born, July 23rd, 1868, at Manchester.

1889. B.Sc. (1st Class Honours in Chemistry). Dalton and Mercer Scholarships in Chemistry.

1889-1890. Research with Dr. L. Claisen at Munich.

1890. Ph.D. Munich. (Summa cum laude).

1890-1892. Research in the Chemical and Physical Laboratories at Owens College. (1851) Exhibition Scholarship.

1892-1893. Research with Professor J. H. van't Hoff, at Amsterdam.

1893-1895. Demonstrator of Chemistry at the Yorkshire College, Leeds.

1894. M.Sc.

1895-1900. Research Chemist to the Aluminium Co. Ltd., Oldbury.

Since 1900. Chief Chemist to the Cassel Gold Extracting Co. Ltd., of Glasgow.

Author of papers dealing mainly with physical and organic chemistry in *Journ. Chem. Soc.*, *Phil. Mag.*, *Journ. State Medicine*, *Journ. Soc. Chem. Ind.*, *Ann. Chem. Pharm.*, *Zeits. Phys. Chem.*, etc., and of the following on work which was wholly or partly carried out in the Physical Laboratories :—

'On the Absorption Spectra of some Copper Salts in Aqueous

Solution." *Phil. Mag.* (5). vol. 33. p.p. 317-342. (1892).
"On the Absorption Spectra of Dilute Solutions." *Proc. Roy. Soc.* vol. 57. p.p. 117-161. (1894).
Also, in conjunction with W. W. HALDANE GEE.
"On the Comparison of Thermometers." *Mem. Manch. Lit. & Phil. Soc.* (4). vol. 4. p.p. 357-364. (1891).

DOUGLAS FARRAR. Born, January 12th, 1881, at Prestwich.
1898-1901. Studied in the Honours School of Physics.
1899. Heginbottom Scholar.
1900. John Buckley Scholar.
1901. B.Sc. (2nd Class Honours in Physics).
1901-1902. Research Assistant to Professor Arthur Schuster.
Since 1902. Assistant Lecturer and Demonstrator in Physics and Electrical Engineering at the University College of North Wales, Bangor.

WILLIAM WINTERBOTTOM FIRTH. Born, June 17th, 1874, at Oldham.
1894-1897. Studied at the Owens College.
1897-1898. Studied Physics and Electrical Engineering in the Physical Laboratories.
1898. B.Sc.
1898-1900. Studied Physics at the Royal College of Science.
1900. A.R.C.S. (1st Class in Physics).
1900. M.Sc.
1900-1902. Demonstrator in Physics and Electrical Engineering at University College, Bangor.
Since 1902. Demonstrator in Mechanical and Electrical Engineering at the Armstrong College, Newcastle-on-Tyne.

FRANK FOSTER. Born July 28th, 1883, at Manchester.
1900-1904. Studied at the Manchester University.
1903. B.Sc. (1st Class Honours Engineering).

1903-1905. Gartside Scholar. Visited American Electrical Engineering establishments.

1904. Electrical Engineering Certificate.

1905. Vulcan Fellow; research in Electrical Engineering.

1906. M.Sc.

Author of several papers on engineering subjects in *Mem. Manch. Lit. & Phil. Soc.*, *Engineer*, etc., etc.

Also of "The Design and Construction of Steam Turbines." Manchester: Scientific Pub. Co. (1906).

DAVID FOULIS. Born, March 28th, 1871, at Edinburgh.

1890-1894. Served Apprenticeship with Messrs. Douglas and Grant, Engineers, Kircaldy, N.B.

1894-1897. Studied Electrical Engineering at the Owens College.

1899. In the Testing Department of Messrs. Siemens & Halske, at Berlin.

Since 1900. Owing to ill health has had to give up Engineering, and is now residing at Aston, Stevenage, Herts., where he has taken up Poultry Farming on an extensive scale.

JULIUS FRITH. Born August 27th, 1873, at Poole, Dorsetshire.

1891-1895. Studied Physics, Electrical and Mechanical Engineering at the Owens College. During the last two years of this period carried on Research work in the Physical Laboratories.

1892. Heginbottom Scholar.

1894. Elected to the (1851) Exhibition Scholarship.

1895-1896. Research at the Central Technical College, London.

1896-1897. Filled a temporary post of Physics Master at Marlborough College.

1897. Joined the Testing Department of Messrs. Mather & Platt, Ltd., Salford.

1904. Appointed Chief of the Designing and Testing Department of Messrs. Mather & Platt, Ltd.

1906. Hon. M.Sc. (Manchester).

Publications whilst connected with the laboratories or holding the 1851 Scholarship:—

"An Analysis of the Electro-motive Force and Current Curves of a Wilde Alternator under Various Conditions." *Mem. Manch. Lit. & Phil. Soc.* (4). vol. 8. p.p. 151-157. (1894).

"On the True Resistance and on the Back Electro-motive Force of the Electric Arc." *Mem. Manch. Lit. & Phil. Soc.* (4). vol. 9. p.p. 139-147. (1895).

"The Effect of Wave Form on the Alternate Current Arc." *Phil. Mag.* (5). vol. 42, p.p. 507-510. (1896); also *Proc. Phys. Soc.* vol. 14. p.p. 245-249. (1896).

Also, in conjunction with CHARLES RODGERS, B.Sc.

"On the Resistance of the Electric Arc." *Phil. Mag.* (5). vol. 42. p.p. 407-423. (1896); also *Proc. Phys. Soc.* vol. 14. p.p. 307-327. (1896).

Also of papers read before Institution of Electrical Engineers.

WILLIAM GANNON. Born, April 12th, 1868, at Dundalk, Ireland. Educated at Grammar School, Galway; Queen's College, Galway; Royal College of Science, Dublin; Owens College, Manchester.

1892. M.A. of Royal University of Ireland; Honours School of Experimental Science (Physics and Chemistry).

1890-1891. Demonstrator and Assistant Lecturer in Physics, Queen's College, Galway.

1891-1892. Post-Graduate student, Physical Laboratories, Owens College, Manchester.

1892-1894. (1851) Exhibition Scholar. Conducted Research at Owens College under Professor Schuster's direction.

1894-1896. Demonstrator and Assistant Lecturer in Physics, Owens College, Manchester.

1896-1900. Science Lecturer and Inspector to the Staffordshire County Council.

1900-1903. Principal of the Technical Institute, Norwich.

Since 1903. Principal of the Woolwich Polytechnic.

Author of the following papers on work carried out in the laboratories:—

"On Copper Electrolysis in Vacuo." *Proc. Roy. Soc.* vol. 55. p.p. 66-83. (1894).

Also, in conjunction with PROFESSOR ARTHUR SCHUSTER.

"A Determination of the Specific Heat of Water in Terms of the International Electric Units." *Phil. Trans.* vol. 186.A. p.p. 415-467. (1895).

WILLIAM WINSON HALDANE GEE. Born, June 29th, 1857, at Bolton, Lancashire. B.Sc. (London). M.Sc. Tech. (Manchester.

1878-1881. Student at the Owens College.

1881-1891. Demonstrator and Assistant Lecturer in Physics at the Owens College. Lecturer of the Victoria University. Extension Lecturer of the Victoria University.

1891-1902. Chief Lecturer in Physics and Electrical Engineering at the Municipal Technical School, Manchester.

Since 1902. Professor of Pure and Applied Physics at the Municipal School of Technology, Manchester. Lecturer of the Manchester University. Has been largely responsible for the design and equipment of the laboratories in Physics, Electrical Engineering, and Electro-Chemistry at the Technical School and School of Technology.

1906. M.Sc. Tech. (Manchester).

Author of several papers on Electro-Chemical and Electrical Engineering Subjects.

Also of the following papers whilst connected with the Physical Laboratories:—

"On a Comparison Magnetometer." *Report Brit. Assoc.* 1887. (Manchester). p. 620.

"A Bibliography of Vicosity." *Mem. Manch. Lit. & Phil. Soc.* (4). vol. 3. p.p. 123-142. (1890).

In conjunction with THOMAS EWAN.

"On the Comparison of Thermometers." *Mem. Manch. Lit. & Phil. Soc.* (4). vol. 4. p.p. 357-364. (1891); also in "Studies from the Physical and Chemical Laboratories of the Owens College." vol. 1. p.p. 71-77. (1893).

In conjunction with ARTHUR HARDEN.

"On New Forms of Stereometers." *Mem. Manch. Lit. & Phil. Soc.* (4). vol. 4. p.p. 301-313. (1891); also in "Studies from the Physical and Chemical Laboratories of the Owens College." vol. 1. p.p. 125-136. (1893).

In conjunction with H. HOLDEN.

"Experiments on Electrolysis. Part I. Change of Density of the Electrolyte at the Electrodes." *Phil. Mag.* (5). vol. 25. p.p. 276-283. (1888); also in *Proc. Phys. Soc.* vol. 9. p.p. 157-165. (1888). ditto "Part II. Irreciprocal Conduction." *Phil. Mag.* (5). vol. 26. p.p. 126-149. (1888); also in *Proc. Phys. Soc.* vol. 9 p.p. 335-361. (1888).

In conjunction with H. HOLDEN *and* C. H. LEES.

"Experiments on Electrolysis and Electrolytic Polarisation." *Report Brit. Assoc.* 1887. (Manchester). p.p. 589-590.

In conjunction with W. STROUD.

"On a Null Method of Electro-Calorimetry." *Report Brit. Assoc.* 1887. (Manchester). p. 581. *Report Brit. Assoc.* 1888. (Bath). p. 565.

In conjunction with HUBERT L. TERRY.

"On the Specific Heat of Non-Conductors." *Mem. Manch. Lit. & Phil. Soc.* (4). vol. 4. p.p. 38-46. (1890); also in "Studies from the Physical and Chemical Laboratories of the Owens College." vol. 1. p.p. 58-65. (1893).

In conjunction with the late PROFESSOR BALFOUR STEWART.

"Lessons in Practical Physics. vol. 1. 1885, vol. 2. 1887, London : Macmillan.

"Lessons in Practical Physics for Schools." 1888. London : Macmillan.

MARY ETHEL GREENGRASS. Born, June 6th, 1882, at Manchester.

1901-1905. Studied at the Manchester University.

1905. B.Sc.

1905. Assistant Mistress, Bridlington High School for Girls.

1906. Assistant Mistress, Manchester High School for Girls.

ALBERT GRIFFITHS. Born, October 8th, 1867, at Chester.

1887-1890. Studied in the Honours School of Physics.

1888. Heginbottom Scholar.

1890. B.Sc. (1st Class Honours in Physics).

1890. Research under Professor Warburg, at Freiburg im Breisgau.

1891. Private Assistant to Professor Schuster.

1891-1892. Demonstrator in Chemistry and Physics at the Hartley College, Southampton.

1892-1893. Research student in Physics at Owens College.

1893-1895. Berkeley Fellow at Owens College.

1895-1898. Demonstrator and Assistant Lecturer in Physics at Owens College.

1898-1900. Demonstrator and Lecturer in Physics at Sheffield University College.

1899. D.Sc.

Since 1900. Head of Physics Department, Birkbeck College, London. Member of Board of Studies for Physics, London University, since 1904. Internal Examiner in Physics, London University, 1905. Member of Science Faculty, 1906.

Author of the following papers on work carried out in the laboratories :—

"Some Experiments with Alternating Currents." *Phil. Mag.* (5). vol. 39, p.p. 229-254. (1895).

"Diffusive Convection." *Phil. Mag.* (5). vol. 46, p.p. 453-465. (1898); also *Proc. Phys. Soc.* vol. 16, p.p. 230-243. (1898).

"Note on the Source of Energy in Diffusive Convection." *Phil. Mag.* (5). vol. 47, p.p. 522-529. (1899); also *Proc. Phys. Soc.* vol. 16, p.p. 435-443. (1899).

"A Study of an Apparatus for the Determination of the Rate of Diffusion of Solids Dissolved in Liquids." *Phil. Mag.* (5). vol. 47, p.p. 530-539. (1899); also *Proc. Phys. Soc.* vol. 16, p.p. 443-454. (1899).

ROGER ERNEST GRIME. Born, September 28th, 1884, at Darwen, Lancashire.

1901-1904. Studied in the Honours School of Physics.

1902. Heginbottom Scholarship.

1904. B.Sc. (1st Class Honours in Physics).

Since 1904. On Staff of Electrical Department, Messrs. Mather & Platt, Ltd.

In conjunction with C. H. LEES, author of the following paper :—

"On a Compact Apparatus for Determining Young's Modulus for thin wires." *Phil. Mag.* (6) vol. 9, p.p. 258-264. (1905).

HERBERT CHARLES GUNTON. Born, April 11th, 1874, at Manchester.

1891-1894. Studied Electrical Engineering at Owens College.

1894-1897. Pupil at the Works of Messrs. Laurence, Scott & Company, Norwich.

1897-1898. Electrical Engineer at Messrs. Peter Brotherhood's Works, London.

Since 1898. On the Staff of Sir Alexander Kennedy and Mr. B. M. Jenkin, Consulting Engineers, Westminster, and Superintending Installation of Plant in connection with the following schemes :—

Dublin Corporation Electric Lighting.

Howth Electric Railway (Gt. Northern Railway Co. of Ireland).

Manchester Corporation Electricity Works—Stuart Street Scheme.

Great Western Railway—Electric Power and Lighting, and Electrification of Hammersmith and City Railway.

HARRY EDWIN HADLEY.

1885-1888. Royal Exhibitioner at the Royal College of Science, London.

1888. A.R.C.S. with Honours in Physics.

1889-1892. Demonstrator in Physics at the Owens College.

1890. B.Sc. (London). (3rd Class Honours in Physics).

Since 1892. Headmaster of the School of Science, Kidderminster.

Author of the following text-books (published by Macmillan & Co.) :—

" Magnetism and Electricity for Beginners."

" Practical Exercises in Magnetism and Electricity."

" Magnetism and Electricity for Students."

FREDERICK ALWYN HAIGH. Born, November, 1881.

1889-1902. Studied in the Honours School of Physics.

1902. B.Sc. (2nd Class Honours in Physics).

ARTHUR HARDEN. Born, October 12th, 1865, at Manchester.

1882-1885. Studied at the Owens College.

1885. B.Sc. (1st Class Honours in Chemistry).

1888. Ph.D. (Erlangen).

1888-1897. Lecturer and Demonstrator in Chemistry, Owens College.

Since 1897. Head of Chemical Department, Lister Institute of Preventive Medicine.

1902. D.Sc.

Author of a number of publications on Chemical and Biochemical Subjects.

Also, in conjunction with W. W. HALDANE GEE, of the following paper on work carried out in the Physical Laboratories :—

"On New Forms of Stereometers." *Mem. Manch. Lit. & Phil. Soc.* (4). vol. 4, p.p. 301-313. (1890); also in "Studies from the Physical and Chemical Laboratories of the Owens College." vol. 1, p.p. 125-136. (1893).

JOHN ALLEN HARKER. Born, January 23rd, 1870, at Alston, Cumberland.

1886-1889. Studied at the Owens College.

1889-1891. Research in Chemical Laboratories, Owens College.

1891. Dalton Chemical Scholarship; research at Tübingen.

1891. D.Sc. (Tübingen).

1892. Returned to Manchester as Research Fellow in Physics.

1892. Berkeley Fellowship in Physics.

1896. Research Assistant at Kew Observatory.

1896-1898. Research on Electric Thermometry at the International Bureau of Weights and Measures, Sèvres.

Since 1901. First Assistant in the Physics Department of the National Physical Laboratory.

1906. M.Sc. of Manchester University. (Research Degree).

Author of a number of papers mostly on thermal and electrical subjects in *Phil. Trans.* and *Proc. Roy. Soc.*, *Phil. Mag.*, *Proc. Phys. Soc.*, etc.

While working in the Physical Laboratory published the following papers :—

"Some Experiments on the Latent Heat of Steam." *Mem. Manch. Lit. & Phil. Soc*, (4), vol. 10, p.p. 38-55. (1896).

"On the Determination of Freezing Points." *Proc. Roy. Soc.*, vol. 60, p.p. 154-156. (1896).

Also, in conjunction with A. DAVIDSON,

"On Reostene, a New Resistance Alloy." *Report Brit. Assoc.* 1896. (Liverpool). p. 714.

In conjunction with P. J. HARTOG,

"On a Delicate Calorimeter." *Report Brit. Assoc.* 1892. (Edinburgh). p. 662.

"Preliminary Experiments on the Latent Heat of Steam." *Mem. Manch. Lit. & Phil. Soc.* (4), vol. 8, p.p. 37-53. (1893).

"On the Latent Heat of Steam." Letter to *Nature*, vol. 49, p. 5. (1893).

In conjunction with JOHN WILD.

"Some Experiments on the Effect of Ultra-Violet Light on Chlorine and Hydrogen." *Electrician*, vol. 38. p.p. 690-692. (1897).

PHILIPPE JOSEPH HARTOG. Born March 2nd, 1864, in London.

1880-1882. Studied at the Owens College.

1882. B.Sc. (Vict.)

1882-1884. Studied at the Sorbonne, Paris, under Troost, Wurtz and Lippmann.

1883. Licencié ès sciences physiques. (Paris).

1884-1885. Studied at Heidelberg, under Bunsen.

1885-1889. Research on Thermo-Chemistry in the Laboratory of M. Berthelot, at the Collège de France, Paris.

1890-1891. Bishop-Berkeley Fellow at Owens College, carrying on research in the Physical and Chemical Laboratories.

1891-1903. Junior and later Senior Assistant Lecturer in Chemistry at the Owens College.

1895-1903. Secretary to the Victoria University Extension Scheme.

1898-1903. Lecturer in the Victoria University.

1901-1903. Member of Court of the Victoria University.

1902-1903. Secretary of the Mosely Commission of Educational Enquiry.

1903. Elected Associate of the Owens College.

Since 1903. Academic Registrar of the University of London.

Author of a number of publications on Chemical and Educational questions.

Editor of "The Owens College, Manchester: A brief History and Description of its Various Departments," Manchester: J. E. Cornish; 1st Edition 1900; 2nd. Edition 1901.

Author of articles on Sir Edward Frankland, Joseph Priestley, Warren de la Rue, Carl Schorlemmer, Balfour Stewart, and many other men of Science, published in the *Dictionary of National Biography*.

Also of the following papers on work carried out in the Physical Laboratories :—

"On the Flame Colouration and Spectrum of Nickel Compounds." *Report Brit. Assoc.* 1901. (Glasgow). p. 613.

Also, in conjunction with J. A. HARKER.

"On a Delicate Calorimeter." *Report Brit. Assoc.* 1892. (Edinburgh). p. 662.

"Preliminary Experiments on the Latent Heat of Steam." *Mem. Manch. Lit. & Phil. Soc.* (4). vol. 8, p.p. 37-53. (1893).

"On the Latent Heat of Steam." Letter to *Nature*. vol. 49, p. 5. (1893).

JOHN WILLIAM PICKLES HAYTON. Born, November 18th, 1871, at Kendal, Westmorland.

1892. A.R.C.Sc. (London).

1892-1895. Demonstrator and Lecturer in Physics at the Owens College.

1894. B.Sc. (Honours Physics). London.

1895-1898. At Trinity College, Cambridge.

1898. B.A. (Nat. Sci. Tripos. Parts I and II).

Since 1899. In business as a Mechanical and Hydraulic Engineer, now being partner in the two firms, J. & C. Hayton, and the Hartley Engine Co., of Bradford, Yorkshire.

JOSEPH WILLIAM HAYWARD. Born, January 24th, 1875, at Winchmore Hill.

1892-1895. Studied in the Owens College.

1894. Studied Electrical Engineering at Owens College.

1895. B.Sc. (1st Class Honours in Engineering), and University Scholarship in Engineering.

1898-1902. Demonstrator in Mechanical and Electro-technical Laboratories, Durham College of Science.

Since 1902. Senior Assistant to Professor W. E. Dalby, in the Engineering Laboratories of the Central Technical College.

Is a member of the Committee of the Institution of Civil Engineers to establish a standard of comparison for Internal Combustion Engines.

GUSTAVUS ADOLPHUS HEMSALECH. Born, May 25th, 1875, at Lodz, Russian Poland.

1885-1892. Magdalenäum and Oberrealschule, Breslau, Germany.

1892-1895. Studied Engineering in Works and at the Yorkshire College, Leeds.

1895-1898. Study and Research in the Physical Laboratories, Owens College.

1898-1901. Research in Professor Lippmann's Laboratory at the Sorbonne, University of Paris.

1901. D.Sc. (Paris).

1901-1902. Research in Professor Fleming's Laboratory, University College, London.

1903-1904. Honorary Research Fellow, University of Manchester.

Since 1905. Attaché au Laboratoire des Recherches Physiques, à la Sorbonne, Paris.

1906. M.Sc. Manchester University. (Research Degree).

Author of numerous papers in the *Comptes Rendus*, *Journal de Physique*, *Drude's Annalen*, etc., and of "Recherches éxpérimentales sur les Spectres d'Etincelles." Paris. A. Hermann. (1901).

Has also published the following papers on work carried out in the laboratories :—

"On Some New Lines in the Spark-Spectrum of Aluminium." *Phil. Mag.* (5). vol. 44, p.p. 289-291. (1897).

"Sur la Constitution de l'Etincelle Eléctrique." *Journal de Physique.* (4). vol. 1, p.p. 76-90. (1902).

"On the Spectrum of the Glow Discharge at Atmospheric Pressure." *Mem. &. Proc. Manch. Lit. & Phil. Soc.* vol. 48 No. 10, p.p. 1-11. (1904).

"Sur une méthode simple pour l'étude des étincelles oscillantes." *Comptes Rendus.* vol. 140, p. 1103. (1905).

"Sur les effets respectifs des courants de Foucault et de l'hystérésis du fer sur les étincelles oscillantes." *Comptes Rendus.* vol. 140, p. 1322. (1905).

"L'Etincelle Electrique." *La Science an XXe Siecle.* vol. 3, p.p. 293-298 and 329-333. (1905).

"Sur les spectres respectifs des differentes phases de l'étincelle. oscillante." *Comptes Rendus.* vol. 141, p. 1227. (1905).

And of the following, in conjunction with PROFESSOR ARTHUR SCHUSTER :—

"On the Constitution of the Electric Spark." *Phil. Trans.* vol. 193. A. p.p. 189-213. (1899); also *Proc. Roy. Soc.* vol. 64, p.p. 331-336. (1899).

ARTHUR MINSHALL HERBERT. Born, November 21st, 1866, at Bowdon, Cheshire.

1884-1887. Studied at Owens College.

1884. Gilchrist Scholarship.

1887. Exhibitioner at King's College, Cambridge.

1887-1891. Nat. Science Tripos. Parts I and II. Aegrotat Degree, 1891.

Since 1901. Spectroscopical Research in the Physical Laboratories of the University of Manchester.

Author of the following Paper on work carried out in the laboratories :—

"The Effect of the Presence of Hydrogen on the Intensity of the Lines of the Carbon Spectrum." *Phil. Mag.* (6). vol. 4, p.p. 202-207. (1902).

EDITH LETTICE HEWLETT. Born, December 10th, 1883, at Brackley, Northants.

1902-1905. Studied in the Honours School of Physics.

1904. B.Sc.

1905. B.Sc. (3rd Class Honours in Physics).

Since 1905. Science Mistress Pupil Teachers' Centre and Secondary School, Middleton, Lancashire.

HARRY HIRST. Born, April 3rd, 1878, at Ashton-under-Lyne.

1900-1903. Studied in the Honours School of Physics.

1903. B.Sc. (3rd Class Honours in Physics).

Since 1903. Assistant Lecturer in Physics and Electrical Engineering, Royal Technical Institute, Salford.

HENRY HOLDEN. Born, January 4th, 1862, at Royton, Lancashire.

1881-1890. At Owens College, except for a short interval in 1888, spent at Würzburg University, Bavaria. Holder of the Watts Exhibition, Lees Exhibition and Rumney Scholarship at Owens College.

1885. B.Sc. (2nd Class Honours in Mathematics).

1888. M.Sc.

1888. Elected to a Berkeley Fellowship in Physics.

1892-1893. Science and Mathematical Master at Shebbear School, N. Devon, and Lecturer on Elementary Chemistry and Agricultural Chemistry for the Devon County Council.

1894-1895. Head of the Physics Department, Currie Technical Schools, Folkestone.

Since 1896. Science and Mathematical Master at Shrewsbury School.

Author of several recent papers on Mathematical Subjects, and of the following papers on work carried out in the laboratories :—

"Measurements of the Magnetic Induction and Permeability in Soft Iron." *Proc. Manch. Lit. & Phil. Soc.* vol. 26, p.p. 9-15. (1886).

"A method of Calculating the Electrostatic Capacity of a Conductor." *Mem. Manch. Lit. & Phil. Soc.* (4), vol. 1 p.p. 112-120. (1890).

Also, in conjunction with W. W. HALDANE GEE.

"Experiments on Electrolysis. Part I. Change of Density of the Electrolyte at the Electrodes." *Phil. Mag.* (5). vol. 25, p.p. 276-283. (1888); also *Proc. Phys. Soc.* vol. 9, p.p. 155-165. (1888). Ditto "Part II. Irreciprocal Conduction." *Phil. Mag.* (5). vol. 26, p.p. 126-149. (1888); and *Proc. Phys. Soc.* vol. 9, p.p. 335-361. (1888).

In conjunction with W. W. HALDANE GEE and C. H. LEES.

"Experiments on Electrolysis and Electrolytic Polarisation." *Report Brit. Assoc.* 1887. (Manchester). p.p. 589-590.

DAVID HOYLE. Born September 21st, 1884, at Blackpool. 1906.

1903-1906. Student in the Honours School of Physics.

WILLIAM ARTHUR HUGHES. Born April 19th, 1881, at Flint.

1901-1903. Studied at the Owens College.
1903. B.Sc.
1904-1906. Assistant Master, Heathside School, Warrington.
1906. Post-Graduate Student in the Physical Laboratories.

JOSEPH HUME HUME-ROTHERY. Born, September 30th, 1886, at Middleton.

1881-1886. Studied at the Owens College.
1887. B.Sc. (London). 1st Class Honours in Physics.
1887-1891. At Trinity College, Cambridge.
1889. Major Scholarship at Trinity College.
1890. Mathematical Tripos, bracketted 12th—16th Wrangler.
1893. Called to the Bar, Lincolns Inn.
1893-1904. In practice in London.
Since 1904. Extension Lecturer for Universities of Oxford and Cambridge.

ROBERT SALMON HUTTON. Born, November 28th, 1876, at Ealing, nr. London.

1894-1897. Studied at the Owens College.
1897. B.Sc. (1st Class Honours in Chemistry).
1897-1898. Research in Physical Laboratories under the direction of Professor Arthur Schuster.
1898-1899. Research with Professor W. Ostwald in Leipzig.
1899-1900. Research with Professor Henri Moissan in Paris.
1900. M.Sc.
Since 1900. Lecturer on Electro-Chemistry in the University of Manchester.
1902. Spent several months in United States and Canada.
1905. D.Sc.
1906. Appointed Assistant Director of the Physical Laboratories.

Author of the following papers on work carried on in the laboratories :—

"Compound Line Spectrum of Hydrogen." *Phil. Mag.* (5). vol. 46, p.p. 338-343. (1898).

"The Electro-chemical Laboratory at Owens College," *Electro-Chemist & Metallurgist.* vol. 1, p.p. 112-114. (1901).

"The Training of an Electro-Chemist." Letter to *Electro-Chemist & Metallurgist.* vol. 1, p. 221. (1901).

"On the Fusion of Quartz in the Electric Furnace." *Mem. & Proc. Manch. Lit. & Phil. Soc.* vol. 46, No. 6, p.p. 1-5. (1901).

"On the Fusion of Quartz in the Electric Furnace." *Trans. American Electrochemical Soc.* vol. 2, p.p. 105-111. (1902).

"Metallurgical and General Notes." Monthly Review for *Electro-Chemist & Metallurgist.* October, 1903, to March, 1904.

Discussion on J. Swinburne's paper on "Chlorine Smelting with Electrolysis." Faraday Soc. *Electro-Chemist & Metallurgist,* vol. 3, p. 88-94. (1903).

"Fifth International Congress of Applied Chemistry in Berlin." Report on Electro-Chemical papers. *Electro-Chemist & Metallurgist.* vol. 3, p.p. 88-94 (1903).

"*Electrolytic Preparations.*" Translation of Book by Professor K. Elbs. London : Ed. Arnold. 1903.

Discussion of R. A. Hadfield's paper on "Alloys of Iron and Tungsten." *Journ. Iron & Steel Inst.* 1903. II.

"Calcium Metal." *Nature* vol. 71, p.p. 180-181. (1904).

Discussion of F. W. Harbord's paper on "Electric Smelting in Connection with Iron and Steel." *Trans. Faraday Soc.* vol. 1, p.p. 170-172. (1905).

Discussion of E. K. Scott's paper on "Refractory Materials for Furnace Linings." *Trans. Faraday Soc.*, vol. 1, p.p. 301-302. (1905).

"The Electric Furnace." *The Electrician Primers*, No. 75. (1905).

"Recent Advances in the Electro-metallurgy of Iron and Steel." *Journ. Soc. Chemical Industry*, vol. 24, p.p. 589-592. (1905).

Review of Adolph Minet's "Le Four Electrique." *Nature*, vol. 72, p. 267. (1905).

In conjunction with J. R. BEARD.

"Notes on Heat Insulation, particularly with regard to Materials used in Furnace Construction." *Trans. Faraday Soc.*, vol. 1, p.p. 264-270. (1905); also *Engineering*. vol. 80, p.p. 64-65. (1905).

In conjunction with W. H. PATTERSON.

"Electrically Heated Carbon Tube Furnaces." Part I. *Trans. Faraday Soc.*. vol. 1, p.p. 187-196. (1905).

In conjunction with J. E. PETAVEL.

"High Temperature Electro-Chemistry. Notes on Experimental and Technical Electric Furnaces." *Journ. Inst. Elec. Eng.*, vol. 32, p.p. 222-247. (1902); also *Engineering*, vol. 74, p.p. 823-830. (1902).

"Note on Carbon and Iron Arc Spectra at High Gaseous Pressures." *Report Brit. Assoc.*, 1903. (Southport). p. 568.

"Preliminary Note on some Electric Furnace Reactions under High Gaseous Pressures." *Report Brit. Assoc.*, 1903. (Southport). p. 630.

"Preliminary Note on the Effect of Pressure upon Arc Spectra." *Phil. Mag.* (6). vol. 6, p.p. 569-577. (1903).

"Preparation and Compression of Pure Gases for Experimental Work." *Journ. Soc. Chemical Industry*, vol. 23, p.p. 87-93. (1904).

In conjunction with W. MURRAY MORRISON.

Discussion of A. Minet's paper on "The Electric Furnace." *Trans. Faraday Soc.*, vol. 1, p.p. 82-83. (1905).

JAMES GRIME ISHERWOOD. Born, January 30th, 1881, at Bolton.

1900-1904. Studied at the University of Manchester.

1903. B.Sc. (2nd Class Honours in Mathematics).

1904. B.Sc. (1st Class Honours in Physics).

1904. University Scholarship.

1904-1905. Lecturer at Woolwich Polytechnic.

Since 1906. Assistant Master, Church Institute Bolton.

Author of the following paper whilst connected with the Physical Laboratories :—

"Tables of Bessel Functions for Pure Imaginary Values of the Argument." *Mem. & Proc. Manch. Lit. & Phil. Soc.*, vol. 48, No. 19, p.p. 1-3 (1904).

DANIEL EVAN JONES. Born, December 21st, 1863, at Carmarthen.

1883-1884. Studied at the Owens College.

1885. B.Sc. London. (1st Class Honours in Chemistry).

1884-1891. Lecturer and subsequently Professor of Physics in the University College of Wales, Aberystwyth.

1891-1894. Director of Technical Education to the Stafford shire County Council.

Since 1894. One of H.M. Inspectors of Schools.

1894-1899. Clerk of the Guild of Graduates of the University of Wales; 1899-1901. Treasurer of the Guild; 1901-1903. Warden of the Guild.

Author of scientific papers and of Text-Books on different branches of Physics; also Translator of Hertz's Scientific Works.

CHARLES HERBERT LEES. Born, 1864, at Glodwick, Oldham. Educated at private school.

1882-1886. Studied in the Owens College.

1885. B.Sc.

1886. B.Sc. (1st Class Honours in Mathematics).

1886. Derby Scholarship and Dalton Senior Mathematical Scholarship.

1886-1887. Post Graduate work in Mathematics and Physics under Professors Lamb and Schuster.

1887-1888. Studied at Strasburg University under Professors Christoffel, Reye, Kundt and Kohlrausch.

1889-1890. Berkeley Fellow of the Owens College.

1891. Studied Electrical Engineering at Central Technical College, London, under Professor Ayrton.

1891. Appointed Senior Assistant Lecturer and Demonstrator in Physics in the Owens College.

1895. D.Sc.

1895. Lecturer of the Victoria University.

1898. Elected Hon. Secretary of the Mathematical and Physical Section of the British Association.

1899. Awarded Wilde Premium for communications to the Literary & Philosophical Society of Manchester.

1900-1906. Lecturer in Physics and Assistant Director of the Physical Laboratories, Manchester University.

1901. Elected Recorder of Mathematical and Physical Section of the British Association.

1901. Elected a Member of the Council of the Manchester Literary & Philosophical Society.

1902. Elected Hon. Secretary of the Manchester Literary & Philosophical Society.

1901-1903. Member of Council of the Manchester Section of Institution of Electrical Engineers.

1903-1905. Chairman of Committee for erecting a Memorial of Joule in Sale Public Park.

1903-1905. Secretary of the Faculty of Science of the University of Manchester.

1906. Elected to Professorship of Physics at East London College.

1906. Elected Fellow of Royal Society.

Author of the following papers whilst connected with the Physical Laboratories.

"On the Law of Cooling, and its Bearing on the Theory of the Motion of Heat in Bars." *Mem. Manch. Lit. & Phil. Soc.* (4). vol. 3, p.p. 57-61. (1889).

"On the Law of Cooling, and its bearing on certain Equations in the Analytical Theory of Heat." *Phil. Mag.* (5). vol. 28, p.p. 429-442. (1889); also "Studies from the Physical and Chemical Laboratories of the Owens College, Manchester," vol. 1, p.p. 34-48. (1893).

"On the Determination of the Thermal Conductivities of Bad Conductors." *Mem. Manch. Lit. & Phil. Soc.* (4). vol. 4, p.p. 17-27. (1890); also "Studies from the Physical and Chemical Laboratories of the Owens College, Manchester." p.p. 49-57. (1893).

"On the Thermal Conductivities of Crystals and other Bad Conductors." *Phil. Trans.*, vol. 183A, p.p. 481-509. (1892); also "Studies from the Physical and Chemical Laboratories of the Owens College, Manchester." vol. 1, p.p. 1-33. (1893).

"On a Simple Geometrical Construction for the Intensity of Illumination at any point of a Plane, due to a Small Source of Light Symmetrical about an Axis Perpendicular to that Plane." *Phil. Mag.* (5). vol. 40, p.p. 463-466. (1895).

"On a Method of Determining the Thermal Conductivities of Salts, with some results of its Application." *Mem. Manch. Lit. & Phil. Soc.* (4), vol. 42, No. 5, p.p. 1-4. (1897).

"On the Thermal Conductivities of Single and Mixed Solids and Liquids and their Variation with Temperature." *Phil. Trans.*, vol. 191. A, p.p. 399-440. (1898).

"On Some Preliminary Experiments on the Effect of Pressure on Thermal Conductivity." *Mem. Manch. Lit. & Phil.*

Soc. (4). vol. 43, No. 8, p.p. 1-6. (1899).

"On the Resistance Between Opposite Sides of a Quadrilateral, one Diagonal of which Bisects the Other at Right Angles." *Mem. Manch. Lit. & Phil. Soc.* (4). vol. 44, No. 1, p.p. 1-3. (1899).

"On the Conductivities of Certain Heterogeneous Media for a Steady Flux having a Potential." *Phil. Mag.* (5), vol. 49, p.p. 221-226. (1900), and *Proc. Phys. Soc.*, vol. 17, p.p. 68-73. (1899).

"On the Thermal Conductivities of Mixtures and of their Constituents." *Phil. Mag.* (5). vol. 49, p.p. 286-293. (1900), and *Proc. Phys. Soc.*. vol. 17, p.p. 73-80. (1899).

"Contribution to Discussion on the Training of Electrical Engineers." *Journ. Inst. Elec. Eng.* vol. 30. p. 789. (1900).

"On the Production of Electrolytic Copper." Letter to *Nature.* vol. 61. p. 392. (1900).

"Report on the Proceedings in Section A. (Physics) at Bradford Meeting of Brit. Assoc." *Nature*, October 4th, 1900.

"On the Vicosities of Mixtures of Liquids and Solutions." *Phil. Mag.* (6). vol. 1. p.p. 128-147. (1901); also *Proc. Phys. Soc.* vol. 17. p.p. 460-480. (1900).

"Mathematics and Physics at Brit. Assoc. Glasgow." *Nature*, October 10th, 1901.

"Mathematics and Physics at Brit Assoc., Belfast." *Nature*, October 16th, 1902.

"Physics at Brit. Assoc., Southport." *Nature*, October 22nd, 1903.

"Physics at Brit. Assoc., Cambridge." *Nature*, September 22nd, 1904.

"On a Simple Graphical Method of Treating the Impact of Smooth Elastic Spheres." *Phil. Mag.* (6). vol. 8. p.p. 215-218. (1904).

"Effects of Temperature and Pressure on the Thermal Conductivities of Solids." Part I. "The Effect of Temperature on the Thermal Conductivities of some Electrical Insulators." *Phil. Trans.* vol. 204.A. p.p. 433-466. (1905).

"Physics at Brit. Assoc., South Africa." *Nature*, October 30th, 1905.

"On the Depression due to a Load at the Centre of an Elastic Chain, tightly stretched between two points in the same Horizontal Plane." *Phil. Mag.* (6). vol. 9. p.p. 811-816. (1905).

"On an Extension of the Fourier Method of Expanding a Function in a Series of Sines and Cosines." *Messenger of Mathematics.* vol. 35 p.p. 152-158 (1906).

Article on W. H. Woollaston, F.R.S., in the *Dictionary of National Biography.* (In conjunction with P. J. Hartog, B.Sc.)

Article on Thomas Young, F.R.S., in the *Dictionary of National Biography.*

Article on D. E. Hughes, F.R.S. in the *Dictionary of National Biography.*

Obituary Notice of Sir G. G. Stokes, F.R.S. in *Manchester Guardian.* February 2nd, 1903.

Obituary Notice of Professor A. Kundt. *Mem. Manch. Lit. & Phil. Soc.* (4). vol. 9. p. 212. (1895).

Obituary Notice of Professor G. Wiedemann. *Mem. Manch. Lit. & Phil. Soc.* vol. 43. p. 36. (1899).

Obituary Notice of Professor H. A. Rowland. *Mem. Manch. Lit. & Phil. Soc.* vol. 46. (1902).

Obituary Notice of Professor P. G. Tait. *Mem. Manch. Lit. & Phil. Soc.* vol. 46. p. 44. (1902).

Reviews of :—Heaviside's "Electrical Papers," Wordingham's "Central Electrical Stations," Clerke's "Problems in Astro-physics," Fahie's "Life of Galileo," etc., in the *Manchester Guardian* of various dates.

In conjunction with J. D. CHORLTON.

"On a Simple Apparatus for Determining the Thermal Conductivities of Cements and other Substances used in the Arts." *Phil. Mag.* (5). vol. 41. p.p. 495-503. (1896).

In conjunction wtih W. W. HALDANE GEE and H. HOLDEN.

"Experiments on Electrolysis and Electrolytic Polarisation.' *Report Brit. Assoc.* 1887. (Manchester). p.p. 589-590.

In conjunction with R. E. GRIME.

"On a Compact Apparatus for Determining Young's Modulus for Thin Wires." *Phil. Mag.* (6). vol. 9. p.p. 528-264. (1905).

In conjunction with PROFESSOR ARTHUR SCHUSTER.

"An Intermediate Course of Practical Physics." (Macmillan & Co). London. First Edition 1896. Reprinted with corrections, 1901 and 1905.

"Advanced Exercises in Practical Physics." (Cambridge University Press). First Edition, 1901. Second Edition (revised). 1905.

In conjunction with R. W. STEWART.

"On Electrolytic Polarisation." *Proc. Manch. Lit. & Phil. Soc.* vol. 25. p.p. 95-102. (1887).

CHARLES HAROLD CORT LIVESEY. Born, August 17th, 1866, at Manchester.

1882-1885. Studied at the Owens College.

1885. B.Sc.

1888. M.Sc.

1888. B.A. Trinity College, Cambridge. (Aegrotat Math. Tripos.)

1892. M.A. (Cambridge).

1893. Barrister-at-law. Inner Temple.

1888-1903. Assistant Master, Cheam School, Surrey.
Since 1903. Science Master, Royal Naval College, Osborne.

HAROLD LOMAS. Born, September 14th, 1875, at Fairfield, near Manchester.

1892-1895. Studied at the Owens College.
1895. B.Sc. (3rd Class Honours in Engineering).
1895-1897. Pupil with Messrs. Laurence Scott, Ltd., Norwich.
1897-1900. With Messrs. R. W. Blackwell & and Co., Ltd., London.
Since 1900. With the Crocker-Wheeler Co., Ampere, New Jersey, U.S.A., being successively manager of their Denver, Washington and Baltimore Branches.

JAMES LORD. Born, October 24th, 1878, at Chadderton, Lancashire.

1895-1898. Studied in the Honours School of Physics.
1898. B.Sc. (2nd Class Honours in Physics).
1899-1900. Research Assistant to Professor Arthur Schuster.
1900-1903. Demonstrator and Assistant Lecturer in Physics in the Owens College.
1901. M.Sc.
1903-1906. Assistant Engineer to the Brush Electrical Engineering Co., Loughborough.
1903-1906. Lecturer in Electric Light and Power Distribution under the Loughborough Education Committee.
1905. Associate Member, Institution Electrical Engineers.

SARAH HANNAH LOWE. Born, August 23rd, 1875, at Salford.

1896-1898. Studied at the Owens College.
1898. B.Sc.
Since 1899. Lecturer in the Edge Hill Training College, Liverpool.

HENRY PONTEFRACT LUNN. Born, February 25th, 1876, at Netherton, Huddersfield.

1898-1900. Studied at the Owens College.

1900. B.Sc.

1900-1901. John Harling Scholarship in Physics. Assisted in Demonstrating in the Physical Laboratories.

1901-1903. Science Master at Academical Institution, Coleraine, Ireland. Supervised Building and Equipment of New Laboratories.

Since 1903. Second Master at County School, Barry, Glamorgan.

JOSEPH LUSTGARTEN. Born, November, 1877, at Botosani, Roumania.

1895-1898. Studied in the Honours School of Physics.

1898. B.Sc. (2nd Class Honours in Physics).

1898-1901. Assistant Lecturer and Demonstrator in Physics and Electrical Engineering in the Hartley University College, Southampton.

1901. M.Sc.

1901-1903. Lecturer in Electrical Engineering, Municipal Technical School, Hull.

Since 1903. Lecturer and Demonstrator in Electrical Engineering, The School of Technology, Manchester.

Joint translator of " Die Prüfung von Gleichstrommaschinen." von. C. Kinzbrunner.

WILLIAM TOLMÉ MACCALL. Born, September 19th, 1878, in Manchester.

1896-1899. Studied at the Owens College.

1899. B.Sc. (1st Class Honours in Engineering).

1899-1900. Studied Electrical Engineering at Owens College.

1900-1902. Assistant in Experimental Department of Messrs. W. T. Glover & Co. Ltd.

1902-1904. Demonstrator in Engineering, Manchester University.

Since 1904. 1st Assistant in Engineering Department of the Woolwich Polytechnic.

JOHN ALEXANDER MCCLELLAND. Born, November 18th, 1870, at Dunallis, Coleraine, Co. Londonderry.

1889-1893. Student Queen's College, Galway.

1893. M.A. (1st Class). Royal University of Ireland.

1894-1895. (1851), Exhibition Scholar at Owens College,

1895. Junior Fellowship, Royal University.

1895-1900. Research Student at Cavendish Laboratory, Cambridge. B.A. (Research) Cantab. Afterwards M.A.

1900. Professorship of Experimental Physics in University College, Dublin.

Fellowship in Royal University.

Author of papers in Journals of Royal Society, Cambridge Philosophical Society, Royal Dublin Society, and in the *Philosophical Magazine.*

JOHN MACPHERSON. Born, February 28th, 1885.

1901-1904. Studied in the Honours School of Physics.

1904. B.Sc. (3rd Class Honours in Physics).

WALTER MAKOWER. Born, December 6th, 1879, in London.

1897-1902. Study and Research, University College, London.

1900. B.Sc. (London). (2nd Class Honours in Chemistry).

1902-1904. Trinity College, Cambridge. Research at the Cavendish Laboratory with Professor J. J. Thomson.

1904. B.A. (Cambridge). Research Degree.

1904-1906. John Harling Fellow. Manchester University.

1906. Appointed Lecturer and Demonstrator in Physics in the University of Manchester.

Author of several papers in the *Proc. Roy. Soc.* and *Phil. Mag.*, and of the following whilst connected with the laboratories :—

"On the Method of Transmission of the Excited Activity of Radium to the Cathode." *Phil. Mag.* (6). vol. 10. p.p. 526-532. (1905); also *Physik. Zeitschrift.* vol. 6. p.p. 915-918. (1905).

"On the Effect of High Temperatures on Radium Emanation." *Proc. Roy. Soc.* vol. 77. A. p.p. 241-247. (1906).

WILLIAM MASON. Born, August 5th, 1872, at Heywood, Lancashire.

1891. Entered as Pupil with Mr. James Diggle, A.M.I.C.E.
1893-1896. Studied at the Owens College.
1896. B.Sc. (1st Class Honours Engineering).
1896. University Scholarship.
1898. B.Sc. (1st Class Honours Physics).
1897-1899. Junior Demonstrator in Engineering, Owens College.
1899. M.Sc.
1899-1902. Contractor's Engineer with C. J. Wills, Esq., and Assistant Engineer, Public Works Department, India.
1902-1905. Demonstrator in Engineering, King's College, London.
Since 1905. Lecturer in Surveying, Liverpool University.

SAMUEL ROSLINGTON MILNER. Born, August 22nd, 1875, at Dodworth, Yorkshire.

1892-1895. Studied at University College, Bristol.
1895. B.Sc. (London). and University Scholar in Physics.
1896-1898. (1851) Exhibition Scholar in Bristol and Göttingen.
1898-1900. Demonstrator of Physics at the Owens College.
1900. D.Sc. (London).

Since 1900. Lecturer in Physics at University College (now the University), Sheffield.

Has published various papers on Physical Subjects in the *Phil. Mag.*, and the following whilst connected with the laboratories :—

" The Theory of Solution Pressure." *Phil. Mag.* (5). vol. 49, p.p. 417-423. (1900).

Also, in conjunction with A. P. CHATTOCK.

" The Thermal Conductivity of Water." *Phil. Mag.* (5). vol. 48, p.p. 46-64. (1899).

WILLIAM MOAT. Born, October 9th, 1867, at Montreal, Canada.

1891. B.A. (Oxford).

1891-1893. Guide Bridge Iron Works.

1893-1896. Studied Electrical Engineering at Owens College,

1896-1898. In charge of Testing Laboratory at The Chloride Electrical Storage Syndicate, Clifton Junction.

Since 1899. Consulting Engineer.

HAROLD MORRIS-AIREY. Born, February 10th, 1880, at Manchester.

1896-1899. Studied in the Honours School of Physics.

1899. B.Sc. (2nd Class Honours in Physics).

1899-1901. Research with Professor Kayser in Bonn.

1901-1903. Assistant in Physical Laboratories, Bonn University.

1903. M.Sc.

1903-1906. Demonstrator in Physics, University of Manchester.

1906. Lecturer in Physics, Armstrong College, University of Durham.

Author of paper in *Wied. Annalen*, and of the following whilst connected with the laboratories :—

" On the Determination of Wave-lengths in the Extreme

Ultraviolet Portion of the Spectrum." *Mem. &. Proc Manch. Lit. & Phil. Soc.* vol. 49, No. 3. p.p. 1-9. (1904).

"On the Rigidity of Gelatine." *Mem. & Proc. of Manch. Lit. & Phil. Soc.* vol. 49, No. 4. p.p. 1-10. (1905).

"On the Resolving Power of Spectroscopes." *Phil. Mag.* (6). vol. 11, p.p. 414-416. (1906).

Also, in conjunction with E. D. SPENCER.

"On a Suitable Arrangement for Determining the Capacity of a Condenser by the Method of Successive Discharges." *Mem. &. Proc. Manch. Lit. &. Phil Soc.* vol. 48. No. 11. p.p. 1-5. (1904).

"On the Temperature Co-efficient of Electrical Resistivity of Carbon at Low Temperatures." *Mem. & Proc. Manch. Lit. & Phil. Soc.* vol. 49, No. 10. p.p. 1-8. (1905).

AMY MULLOCK. Born, August 10th, 1869, at Sale, Cheshire.

1886-1889. Studied at the Owens College.

1889. B.Sc. (2nd Class Honours Mathematics).

1905. M.Sc. (Manchester).

1890. Teacher's Diploma. Cambridge.

1890-1902. Mathematical Mistress, Oxford High School.

Since 1903. Lecturer, Cambridge Training College.

JOHN WILLIAM NICHOLSON. Born, November 1st, 1881, at Darlington.

1899-1900. Studied in the Chemical Department at the Owens College.

1900-1902. Studied in the Honours School of Physics.

1901. John Buckley Scholarship; also Sizarship for Mathematics at Trinity College, Cambridge.

1902. B.Sc. (1st Class Honours in Physics), and University Scholarship.

1902. Entered Trinity College, Cambridge.

1903. B.Sc. (London), (1st Class Honours in Mathematics and Physics).

1904. 10th Wrangler in Part I. Mathematical Tripos.

1905. 1st Class Mathematical Tripos Part II.

1906. Elected to Isaac Newton Studentship in the University of Cambridge, and now engaged in Research in Mathematical Physics.

Author of a number of papers in the *Phil. Mag.* and *Journal, London Mathematical Society.*

WILLIAM HAMILTON PATTERSON. Born, April 23rd, 1882, at Ramsey, Isle of Man.

1901-1904. Studied at the Manchester University.

1904. B.Sc. (3rd Class Honours in Chemistry).

1904-1905. Research in Electro-Chemical Laboratory.

1905-1906. Research at the Technische Hochschule Karlsruhe under Professor F. Haber.

In conjunction with R. S. HUTTON, author of the following paper, whilst connected with the laboratories :—

" Electrically Heated Carbon Tube Furnaces." Part I. *Trans. Faraday Soc.* vol. 1, p.p. 187-196. (1905).

JOSEPH ERNEST PETAVEL. Born, August 14th, 1873, in London.

1892-1896. Studied Mechanical and Electrical Engineering at University College, London ; and Civil Engineering at Lausanne, Switzerland.

1895. Awarded Salomons Scholarship by the Institution of Electrical Engineers.

1896-1899. Elected to 1851 Exhibition Scholarship. Worked at the Royal Institution and at the Davy Faraday Research Laboratory, London.

1897. Passed the Associates' Examination of the Institution of Civil Engineers, and was elected an Associate Member of this Institution and of the Institution of Electrical Engineers.

1900-1903. John Harling Fellow of the Owens College, Manchester.

1904. Scientific Manager of the Low Temperature Exhibit of the British Royal Commission for the St. Louis Exhibition.

Since 1905. Engaged in Research in the Physical Laboratories of the Manchester University. (Honorary Research Fellowship).

1906. M.Sc. of Manchester University. (Research Degree).

Author of a number of papers in the *Phil. Trans.* and *Proc.* of the *Royal Society. Phil. Mag.*, etc., and of the following on work carried out in the laboratories :—

'The Heat Dissipated by a Platinum Surface at High Temperatures. Part IV. Thermal Emissivity in High-pressure Gases." *Phil. Trans.* vol. 197, p.p. 229-254. (1901); also *Proc. Roy. Soc.* vol. 58, p.p. 246-247. (abstract).

" On a Recording Manometer for High Pressure Explosions." *Report Brit. Assoc.* 1901. (Glasgow). p. 768.

" On the Measurement of High-Pressure Explosions." *Mem. & Proc. Manch. Lit. & Phil. Soc.* vol. 46, No. 5. p.p. 1-16. (1901).

" A Recording Manometer for High-Pressure Explosions." *Phil. Mag.* (6). vol. 3, p.p. 461-471. (1902).

" Some Experiments on Radiation and Absorption. A Preliminary Study for a Standard of Light." *Report Brit. Assoc.* 1902. (Belfast). p.p. 534-535.

" A Preliminary Study for a New Standard of Light." *Electrician*, vol. 50, p.p. 1012-1015. (1903).

" On the Rate of Combustion and Explosive Pressure of Cordite." *Report Brit. Assoc.* 1903. (Southport). p.p. 556-557.

" Description of the Low Temperature Exhibit of the British

Royal Commission for the St. Louis Exhibition, 1904." *Catalogue of British Exhibits.* (unsigned).

"The Pressure of Explosions. Experiments on Solid and Gaseous Explosives. Parts I and II." *Phil. Trans.*, vol. 205A., p.p. 357-398. (1905); also *Engineering*, vol. 81, p.p. 429-433. (1906); *Proc. Roy. Soc.*, vol. 75, p.p. 492-494. (abstract).

Capt. Bruce Kingsmill. "Mr. Petavel's Recording Gauge Applied to Ordnance and Small Arms." *Report Brit. Assoc.* 1902 (Belfast), p. 538; also *Engineering*, October 24th, 1902, and March 13th, 1903.

Also, in conjunction with R. S. HUTTON.

"High Temperature Electro-Chemistry. Notes on Experimental and Technical Electric Furnaces." *Journ. Inst. Eng.*, vol. 32, p.p. 222-247. (1902); also *Engineering*, vol. 74, p.p. 823-830. (1902).

"Note on Carbon and Iron Arc Spectra at High Gaseous Pressures." *Report Brit. Assoc.*, 1903. (Southport). p. 568.

"Preliminary Note on some Electric Furnace Reactions under High Gaseous Pressures," *Report Brit, Assoc.*, 1903. (Southport), p. 630.

"Preliminary Note on the Effect of Pressure upon Arc Spectra." *Phil. Mag.* (6), vol. 6, p.p. 569-577. (1903).

"Preparation and Compression of Pure Gases for Experimental Work." *Journ. Soc. Chemical Industry*, vol. 23, p.p. 87-93. (1904).

AGNES M. POYNTING. Born, April 17th, 1876, at Manchester.

1892-1898. Studied at Ladies' College, Cheltenham.

1899. Studied Physics at the Owens College.

1899. B.Sc. (London).

1903-1904. Examiner in Physics for Lancashire and Cheshire Union of Institutes.

1906. Examiner in General Elementary Science for Lancashire and Cheshire Union of Institutes.

OHN NORMAN PRING. Born, April 26th, 1884, at Sandbach, Cheshire.

1901-1904. Studied at the Owens College.

1904. B.Sc. (1st Class Honours in Chemistry).

1904-1906. Research in Electro-Chemical Laboratory.

1905. Appointed to Gartside Scholarship in Economics.

1906. M.Sc.

Author of the following paper on work carried out in the laboratories :—

" The Reduction of Metallic Oxides by Aluminium Carbide." *Journal of the Chem. Soc.*,vol. 87, p.p. 1530-1540. (1905).

HEODORA PRIOR. Born, June 24th, 1882, at Manchester.

1899-1903. Studied at the Owens College.

1902. B.Sc.

1903. Teachers' Diploma of the Victoria University.

1903-1905. Science and Mathematical Mistress at County School, Llandrindod Wells.

Since 1905. Mathematics Mistress at Wynthrop College, Ashton-on-Mersey.

LPHONSO FRITZALAN QUARMBY. Born, June 28th, 1880.

1898-1901. Studied in the Honours School of Physics.

1901. B.Sc. (3rd Class Honours in Physics).

1901. Entered Medical School.

ATHERINE RADFORD. Born, March 15th, 1880, at Ambergate, Derbyshire.

1895-1900. Studied at University College, Sheffield.

1900. B.Sc. (London). (3rd Class Honours in Physics).

1900-1902. Study and Research at University College, Sheffield.

1902. Elected to 1851 Exhibition Probationary Bursary.

1903-1905. (1851) Exhibition Scholar, carrying on Research in the Physical Laboratories of the Manchester University.

Since 1905. Science Mistress at the Manchester High School.

EDWARD REEVE. Born, July 3rd, 1875, at Uttoxeter.
1894-1897. Studied in the Honours School of Physics.
1897. B.Sc. (3rd Class Honours in Physics).
1897-1898. Assistant Master, St. Martin's School, York.
1898-1900. At University School, Southport.
Since 1900. At Ashford Grammar School, Kent.

HENRY REYNOLDS. Born, May 29th, 1873, at Manchester.
1889-1893. Studied at the Owens College.
1893. B.Sc.
1894. In Sir Howard Grubb's Optical Works, Dublin.
1894-1895. Studied in Chemical Department, Manchester Technical School.
1896. Science Master in the Modern School, Fareham.
1896-1897. Head of Chemical Department, Swindon and North Wilts. Technical School.
1897-1899. Studied in the Technische Hochschule, Darmstadt.
1899-1902. Research with Professor Nernst at Göttingen.
1902. Ph.D. Göttingen (Magna cum laude).
Since 1903. Head of the Chemical Department in the L.C.C. Technical Institute, Paddington.
Joint author with PROFESSOR NERNST of paper in *Göttinger Nachrichten*.

WILLIAM GOULD RHODES. Born, August 20th, 1867, at Audenshaw.
1887-1890. Studied at the Owens College.
1890. B.Sc. (1st Class Honours in Mathematics) and Derby Prize.
1892-1893. Demonstrator in the Physical Laboratories.
1893. M.Sc.
1894-1896. Demonstrator in Applied Physics, Central Technical College, London.

1896-1900. Lecturer in Physics and Mathematics at the Royal Technical Institute, Salford.

Since 1900. Consulting Electrical Engineer.

1902. D.Sc.

Since 1905. Lecturer in Electrical Engineering at the Royal Technical Institute, Salford.

Author of papers in the *Proc. Roy. Soc.*, *Phil. Mag.*, *Electrical Review*, etc and of "*An Elementary Treatise on Alternating Currents*" (Longmans, Green & Co., London.) 1901.

JOE RIGBY. Born, June 13th, 1879, at Bolton.

1899-1901. Studied at the Owens College.

1901. B.Sc.

1901-1902. Held John Harling Scholarship in the Physical Laboratories.

1902-1906. Physics Master at the Hanley Municipal Secondary School

1904. M.Sc.

1906. Appointed Assistant Master at the Central Secondary School, West Ham.

Has designed a Magnetic Balance (Messrs. P. Harris & Co).

TRAVIS RIMMER. Born, September 27th, 1881, at Rochdale.

1900-1903. Studied in the Honours School of Physics.

1903. B.Sc. (1st Class Honours in Physics).

1903-1905. Research Assistant to Professor Arthur Schuster.

1905. Elected to (1851) Exhibition Scholarship.

Since 1905. Research with Professor Pernter, in Vienna.

HARRY ROBINSON. Born, September 21st, 1884, at Accrington.

1902-1905. Studied Electrical Engineering at the Manchester University.

1905. Electrical Engineering Certificate, Manchester University.

Since 1905. Junior Assistant to the Newcastle-on-Tyne Electric Supply Co.

ERNEST SMITH AWMACK ROBSON. Born May 12th, 1873, at Sale, near Manchester.

1892-1895. Studied at the Owens College.

1895. B.Sc.

1898. M.Sc.

1895-1897. Science Master, Rochdale.

1897-1904. Lecturer in Physics at the Royal Technical Institute, Salford.

Since 1904. Principal of the Warrington Secondary School and Technical Institute.

Author of "*Exercises in Practical Heat*" (Macmillan) 1902; "*Report of a Visit to American Educational Institutions*" (Sherratt and Hughes). 1905.

SIMON ROSENBAUM. Born April 28th, 1877, at Manchester.

1896-1899. Studied in the Honours School of Physics.

1897. Heginbottom Scholar.

1899. B.Sc. (2nd class Honours in Physics).

1899-1900. Assistant Demonstrator at Central Technical College, S. Kensington.

1901-1903. Lecturer in Physics, Univ. Tutorial College, London.

Since 1903. Statistician to the Tariff Reform Commission.

Author of Recent Papers on Statistical Subjects before British Association, Royal Statistical Society, etc.

THOMAS ROYDS. Born April 11th, 1884, at Oldham.

1903-1906. Student in Honours School of Physics.

1904. Heginbottom Scholarship.

1906.

IDNEY RUSS. Born December 2nd, 1879, in London.

1900-1905. Studied at University College, London.

1904-1905. Clothworkers' Scholar.

1905. B.Sc. (1st Class Honours in Physics).

1905-1906. Research at University College.

1906. Appointed Demonstrator in the Physical Laboratories of the Manchester University.

IERMAN EMIL SCHMITZ. Born September 8th, 1865, at Leeds.

1885-1887. Studied at the Yorkshire College, Leeds.

1887. B.Sc. (London). (1st Class Honours in Physics).

1890. Mathematical Tripos, Cambridge. (27th Wrangler).

1891. Nat. Science Tripos Pt. ii, Cambridge.

1891-1892. Mathematical and Chemistry Master, Grammar School, Louth, Lincs.

1892-1904. Physics Master, Manchester Grammar School.

1902-1904. Research in Physical Laboratories, University of Manchester.

1904-1906. Research in the Laboratory of Prof. E. Riecke at Göttingen.

Author of papers in the *Phil. Mag.*, *Physik. Zeitschrift*, etc., and of the following whilst connected with the laboratories :—

"On the Determination of Specific Heats, especially at Low Temperatures." *Proc. Roy. Soc.*, vol. 72, p.p. 177-193. (1903).

"On a Method of Ice Calorimetry." *Mem. Manch. Lit.& Phil. Soc.*, vol. 48, No. 3, p.p. 12-20. (1903-4).

"On the Specific Heats and Specific Volumes of Certain Alloys." *Mem. Manch. Lit. & Phil. Soc.* vol. 48, No. 6. p.p. 1-8. (1903-4).

VILFRED SESSIONS. Born September 17th, 1868, at Gloucester.

1888-1892. Studied at the Owens College.

1892. B.Sc. (London.)

1891-1897. Science Master, Leighton Park School, Readi
1897-1898. Post-Graduate work at Heidelberg Universi
1899-1906. Headmaster of Stramongate School, Kendal.

WILLIAM BOLTON SHAW. Born April 18th, 1876, at Durham.
1892-1896. Studied at the Owens College.
1894. Heginbottom Scholarship.
1894-1895. Whitworth Meteorological Observer.
1895. B.Sc.
1896. B.Sc. (2nd Class Honours in Physics).
1896-1902. With Messrs. C. A. Parsons & Co., Newcastle-o Tyne.
1898. M.Sc.
Since 1902. Electrical Engineer to Hulton Colliery Co., Lt

ROBERT ACHESON SHELDON, of Belfast. Born August 1 1880, at Bristol.
1898-1901. Studied at the Owens College.
1901. B.Sc. (3rd Class Honours in Engineering).
1901-1902. Studied Electrical Engineering at the Owe College.
1904. Electrical Engineering Certificate.
1904. M.Sc.
1902-1905. With Messrs. Mather & Platt, Salford Iro Works.
Since 1906. Assistant Lecturer and Demonstrator Engineering, University College, Nottingham.

GEORGE CLARKE SIMPSON. Born September 2nd, 1878, at Derb
1897-1900. Studied in the Honours School of Physics.
1898. Heginbottom Scholar.
1899. John Buckley Scholar.
1900. B.Sc. (1st Class Honours in Physics), and Universi Scholar.
1901. University Fellow.

1900-1902. Research in Physical Laboratory.

1902-1904 (1851) Exhibition Scholar.

1901-1902. Studied under Professor Wiechert in Göttingen.

Oct. 1902-Nov. 1903. Observational Work on Atmospheric Electricity in Karasjok, Lapland.

1903. M.Sc.

March-Sept. 1905. Honorary Scientific Assistant to the Director of the Meteorological Office, London.

Since 1905. Lecturer in Meteorology and Assistant Lecturer in Physics, Manchester University.

Publications whilst connected with the laboratories or holding the 1851 Scholarship :—

"On the Electrical Resistance of Bismuth to Alternating Currents in a Strong Magnetic Field, Part I." *Phil. Mag.* (6), vol. 2, p.p. 300-311. (1901).

"On the Electrical Resistance of Bismuth to Alternating Currents in a Magnetic Field, Part II." *Phil. Mag.* (6,) vol. 4, p.p. 554-560. (1902).

"Ueber den Volta-Effekt." *Physik. Zeits.* vol. 4, p. 480. (1903).

"On Charging through Ion Absorption and its bearing on the Earth's Permanent Negative Charge." *Phil. Mag.* (6), vol. 6, p.p. 589-598. (1903).

"Ueber die Ursache des normalen atmosphärischen Potentialgefälles und der negativen Erdladung (Bemerkungen zu Professor Ebert's Theorie)." *Physik. Zeits.* vol. 5, p.p. 325-326. (1904).

"Atmospherical Radio-Activity in High Latitudes." *Proc. Roy. Soc.*, vol. 73, p.p. 209-216. (1904).

"Ueber das normale elektrische Feld der Erde." *Physik. Zeits.* vol. 5, p.p. 734-736. (1904).

"Atmospheric Electricity in High Latitudes." *Phil. Trans.* vol. 205. A. p.p. 61-97. (1905); also *Proc. Roy. Soc.* vol. 76. A. p.p. 160-164. (1905).

1891-1897. Science Master, Leighton Park School, Reading.
1897-1898. Post-Graduate work at Heidelberg University.
1899-1906. Headmaster of Stramongate School, Kendal.

WILLIAM BOLTON SHAW. Born April 18th, 1876, at Durham.
1892-1896. Studied at the Owens College.
1894. Heginbottom Scholarship.
1894-1895. Whitworth Meteorological Observer.
1895. B.Sc.
1896. B.Sc. (2nd Class Honours in Physics).
1896-1902. With Messrs. C. A. Parsons & Co., Newcastle-on-Tyne.
1898. M.Sc.
Since 1902. Electrical Engineer to Hulton Colliery Co., Ltd.

ROBERT ACHESON SHELDON, of Belfast. Born August 1st, 1880, at Bristol.
1898-1901. Studied at the Owens College.
1901. B.Sc. (3rd Class Honours in Engineering).
1901-1902. Studied Electrical Engineering at the Owens College.
1904. Electrical Engineering Certificate.
1904. M.Sc.
1902-1905. With Messrs. Mather & Platt, Salford Iron Works.
Since 1906. Assistant Lecturer and Demonstrator in Engineering, University College, Nottingham.

GEORGE CLARKE SIMPSON. Born September 2nd, 1878, at Derby.
1897-1900. Studied in the Honours School of Physics.
1898. Heginbottom Scholar.
1899. John Buckley Scholar.
1900. B.Sc. (1st Class Honours in Physics), and University Scholar.
1901. University Fellow.

1900-1902. Research in Physical Laboratory.

1902-1904 (1851) Exhibition Scholar.

1901-1902. Studied under Professor Wiechert in Göttingen.

Oct. 1902-Nov. 1903. Observational Work on Atmospheric Electricity in Karasjok, Lapland.

1903. M.Sc.

March-Sept. 1905. Honorary Scientific Assistant to the Director of the Meteorological Office, London.

Since 1905. Lecturer in Meteorology and Assistant Lecturer in Physics, Manchester University.

Publications whilst connected with the laboratories or holding the 1851 Scholarship :—

"On the Electrical Resistance of Bismuth to Alternating Currents in a Strong Magnetic Field, Part I." *Phil. Mag.* (6), vol. 2, p.p. 300-311. (1901).

"On the Electrical Resistance of Bismuth to Alternating Currents in a Magnetic Field, Part II." *Phil. Mag.* (6,) vol. 4, p.p. 554-560. (1902).

"Ueber den Volta-Effekt." *Physik. Zeits.* vol. 4, p. 480. (1903).

"On Charging through Ion Absorption and its bearing on the Earth's Permanent Negative Charge." *Phil. Mag.* (6), vol. 6, p.p. 589-598. (1903).

"Ueber die Ursache des normalen atmosphärischen Potentialgefälles und der negativen Erdladung (Bemerkungen zu Professor Ebert's Theorie)." *Physik. Zeits.* vol. 5, p.p. 325-326. (1904).

"Atmospherical Radio-Activity in High Latitudes." *Proc. Roy. Soc.*, vol. 73, p.p. 209-216. (1904).

"Ueber das normale elektrische Feld der Erde." *Physik. Zeits.* vol. 5, p.p. 734-736. (1904).

"Atmospheric Electricity in High Latitudes." *Phil. Trans.* vol. 205. A. p.p. 61-97. (1905); also *Proc. Roy. Soc.* vol. 76. A. p.p. 160-164. (1905).

"Atmospheric Electricity from Balloons." *Nature*, vol. 72, p.p. 92-93. (1905).

"Normal Electrical Phenomena of the Atmosphere." *Quart. Journ. R. Met. Soc.*, vol. 31, p. 295. (1905).

"Kite-flying for Meteorological Purposes." *Quart. Journ. R. Met. Soc.*, vol. 32, p. 15. (1906).

"The Beaufort Scale of Wind Force." *Publications of the Meteorological Office*. No. 180. (1906).

DORA FRANCES SLADE. Born, September 28th, 1874, at Little Lever, Bolton-le-Moors.

1899. Studied Physics at the Owens College.

Since 1900. Mathematics Mistress at the Ladies' College Guernsey.

FOSTER SMITH. Born November 1st, 1875, at Bradford.

1893-1896. Studied at Owens College.

1895. Heginbotton Scholar in Physics.

1896. B.Sc.

1896-1904. Second Master (Science and Mathematics) at the County Intermediate School, Holywell, North Wales.

Since 1904. Lecturer in Physics in the Royal Technical Institute, Salford.

EDWARD DUGDALE SPENCER. Born, January 8th, 1883, at Blackburn.

1901-1905. Studied Electrical Engineering in the Manchester University.

Since 1905. Assistant in the Testing Department, Messrs. Mather & Platt, Salford.

In conjunction with H. MORRIS-AIREY, author of the following papers, whilst connected with the laboratories :—

"On a Suitable Arrangement for Determining the Capacity of a Condenser by the Method of Successive Discharges."

Mem. &. Proc. Manch. Lit. & Phil. Soc., vol. 48, No. 11, p.p. 1-5. (1904).

" On the Temperature Co-efficient of Electrical Resistivity of Carbon at Low Temperatures." *Mem. & Proc. Manch. Lit. & Phil. Soc.*, vol. 49, No. 10, p.p. 1-8. (1905).

EDGAR STANSFIELD. Born, August 25th, 1878, at Bradford.

1897-1900. Studied at the Owens College.

1900. B.Sc. (2nd Class Honours in Chemistry).

1900-1901. Research in the Electro-Chemical Laboratory.

Since 1901. Demonstrator in Chemistry at the Sunderland Technical College.

Author of the following paper on work carried out in the laboratories :—

" Preliminary Note on the Preparation of Barium." *Mem. & Proc. Manch. Lit. & Phil. Soc.* vol. 46. No. 4. p.p. 1-6. (1901) ; also *Annales de chimie et de physique*, (7), vol. 25, p.p. 284-288. (1902).

HERBERT STANSFIELD. Born, October 22nd, 1872, at Bradford.

1889-1894. Study and Research at the Royal College of Science, London, taking Physics with Professors Rücker and Boys.

1893-1894. Demonstrator in Physical Laboratory, Royal College of Science, London.

1894-1896. In charge of Physics Classes for evening students at the East London Technical College ; continuing Research at the Royal College of Science.

1896-1898. Lecturer in the Physics and Electrical Engineering Department at the Chelsea Polytechnic.

1898. B.Sc. (London). 1st Class Honours in Physics.

1898-1904. Principal of the Physics and Electrical Engineering Department of the Blackburn Municipal Technical School.

1904-1905. Hon. Research Fellowship in Physical Laboratories, Manchester University.

1906. Appointed Demonstrator in Physical Laboratories.

Author of the following papers whilst connected with the laboratories :—

"A Simple Pattern of Michelson Interferometer." *Proc. of the Optical Convention I*, p.p. 90-98 (1905.)

"Observations and Photographs of Black and Grey Soap Films." *Proc. Roy. Soc.*, vol. 77 A, p.p. 314-323, (1906).

SAMUEL STANSFIELD. Born, July 13th, 1872, at Todmorden.

1891-1894. Studied at the Owens College.

1894. B.Sc. (2nd Class Honours in Engineering) and Engineering Certificate with Honours in Physics.

1894-1897. Studied at Royal College of Science under Professors Rücker, Boys and Perry.

1897. A.R.C.S. (1st Class in Physics).

1897-1901. Engaged in Engineering work with the late Mr. Latimer Clark, F.R.S., and Messrs. Clark & Standfield.

1899. A.M.I.C.E.

1901-1905. With Messrs. Heenan and Froude, Engineers, Manchester.

Since 1905. Head of the Engineering Department under Middlesborough Education Committee.

Author of several papers on Engineering Subjects.

ARTHUR T. STANTON.

1881. B.Sc. Edinburgh University, in the Department of Physical Experimental Science.

1883-1898. Private Research Assistant to Professor Arthur Schuster.

1898. Deceased.

Author of the following papers on work carried out in the laboratories :—

"The Discharge of Electricity from Glowing Metals." *Proc.*

Roy. Soc., vol. 47, p.p. 559-561. (1890).

"On Practically Available Processes for Soldering Aluminium in the Laboratory." *Nature*, vol. 56, p.p. 353-354. (1897).

ALFRED ERNEST STEINTHAL. Born, May 5th, 1858, at Liverpool.

1873-1877. Studied at the Owens College. Subsequently entered Trinity College, Cambridge.

1879. B.A. (London). 1st Class Honours in Mathematics.

1881. B.A. (Cambridge). 3rd Wrangler and 2nd Smith's Prizeman.

1881. M.A. (London). Gold Medallist.

1882. Elected to a Fellowship at Trinity College.

1884. M.A. (Cambridge). Called to the Bar at Lincolns Inn.

1886-1888. Gave special courses of Law Lectures at the Owens College.

1895. Appointed Assistant Registrar of the Lancaster County Court.

1898-1904. Clerk of Convocation of the Victoria University.

Since 1900. Member of the Court of the University.

Since 1904. Chairman of Convocation.

EDWARD THEODOR STEINTHAL. Born, December 30th, 1872, at Manchester.

1890-1893. Studied Electrical Engineering at the Owens College.

1893-1897. Pupil at works of Messrs. Royce & Co., Manchester.

Since 1897. Manager of the Manchester Branch, and since 1903 partner in the firm of G. A. Steinthal & Co.

WILLIAM PAUL STEINTHAL. Born, September 30th, 1871, at Manchester.

1889-1892. Studied in the Honours School of Physics.

1892. B.Sc. (3rd Class Honours in Physics).

1897. M.Sc.

1893-5. After leaving the Owens College, spent two years in works, and was then sent to Scotland as Assistant Engineer to the Brush Electrical Engineering Co.

Since 1895, in business as Electrical Engineer. Designed and carried out during this period the electric lighting of the Manchester Museum and other College buildings. Has also carried out a considerable portion of the experimental electric equipment for the Physical Laboratories, under the direction of Dr. Schuster.

Author of paper "On the Electrical Equipment of the New Physical Laboratories, Owens College." *Electrical Review* (London), vol. 48, p.p. 615-618. (1901).

ROBERT WALLACE STEWART. Born, November 10th, 1858, at Campbeltown.

1882-1886. Studied at University College, Aberystwyth.

1887-1889. Studied at the Owens College.

1889. Student-Assistant in the Physical Laboratories, University College, Aberystwyth.

1889-1890. Science Tutor of University Correspondence and University Tutorial Colleges, Cambridge and London.

1890-1894. Lecturer and Demonstrator in Physics, University College of North Wales, Bangor.

1893. D.Sc. (London).

1894-1900. Principal of Hartley University College, Southampton.

1900-1902. Principal of Harris Institute, Preston.

Since 1902. Science Organiser for London School Board, now for London County Council Education Department.

Author of papers in the *Phil. Trans.* etc., of several Text Books on different branches of Physics, and *in conjunction with* C. H. LEES of the following paper on work carried out in the laboratories :—

"On Electrolytic Polarisation." *Proc. Manch. Lit. & Phil.*

Soc., vol. 25, p.p. 95-102. (1887).

EDGAR SUTCLIFFE. Born, November 10th, 1882, at Macclesfield.

1899-1902. Studied in the Honours School of Physics.

1902. B.Sc. (2nd Class Honours in Physics).

Since 1902. Science Master, Catholic Day College, Preston.

1905. M.Sc.

ALICE JANE TAYLOR. Born, December 17th, 1884, at Matlock.

1903-1906. Student in the Honours School of Physics.

1906.

HUBERT LANPHIER TERRY. Born, May 8th, 1865, at Oving, Bucks.

1882-1885. Studied Chemical Technology at the Owens College.

1885-1895. Chemist to Messrs. Chas. Macintosh & Co. Ltd., Indiarubber Works, Manchester.

1895-1901. Chemist and Departmental Manager, United Alkali Co., Ancoats.

Since 1901. Analytical and Consulting Chemist, Manchester.

Author, *in conjunction with* W. W. HALDANE GEE, of the following paper on work carried out in the laboratories :—

"On the Specific Heat of Non-Conductors." *Mem. Manch. Lit. & Phil. Soc.* (4), vol. 4, p.p. 38-46. (1890); also in "Studies from the Physical and Chemical Laboratories of the Owens College," vol. 1, p.p. 58-65. (1893).

JOHN TOMLINSON. Born, January 6th, 1874, at Preston.

1896-1899. Studied in the Honours School of Physics.

1899. B.Sc. (3rd Class Honours in Physics).

1900-1903. Science and Mathematical Master, Kent College, Canterbury.

1902. M.Sc.

1904. Mathematical Master, Grammar School, Ashly-de-la-Zouch.

Since 1904. Mathematical Master, County School, Dover.

FREDERICK UNWIN. Born, September 3rd, 1882, at Stockport.

1900-1903. Studied in the Honours School of Physics.

1903. B.Sc. (1st Class Honours in Physics).

Since 1903. Demonstrator in Physics in the Heriot-Watt College, Edinburgh.

THOMAS WADSWORTH. Born, January 12th, 1880, at Stretford.

1899-1903. Studied in the Honours School of Physics, and carried out advanced work in Electrical Engineering.

1903. B.Sc. (2nd Class Honours in Physics).

1903-1905. Lecturer in Electrical Technology, Chelsea Polytechnic.

Since 1905. In partnership as Scientific and Electrical Instrument maker. Messrs. Clark Fisher & Wadsworth, Ealing, London.

ROYDEN COBDEN WALE. Born, May 14th, 1879, at Oldham.

1897-1900. Studied in the Honours School of Physics.

1900. B.Sc. (2nd Class Honours in Physics).

1900-1903. Demonstrator in Physics, Owens College.

1902-1903. Whitworth Meteorological Observer.

Since 1903. Assistant Examiner, H.M. Patent Office, London.

CHARLES FRÉDÉRIC DE WATTEVILLE. Born, June 11th, 1870, at Geneva.

1893. Licencié en Droit. (Paris).

1894. Licencié ès Sciences Physiques. (Paris).

1894-1901. Research with Professors Hautefeuille and Lippmann, in Paris.

1901-1904. Spectroscopical Research with Professor Arthur Schuster.

1904. D.Sc. (Paris).

1906. M.Sc. (Manchester) Research Degree.

Author of several papers in the *Comptes Rendus* and of the following on work carried out in the laboratories :—

" Sur les Spectres de Flammes." *Comptes Rendus*. vol. 135, p.p. 1329-1332. (1902).

" Sur les Spectres de flammes des métaux alcalins." *Comptes Rendus*, vol. 138. p.p. 346-349. (1904).

" Sur le Spectre de l'arc." *Comptes Rendus*, vol. 138, p.p. 485-486. (1904).

" On Flame Spectra." *Phil. Trans.*, vol. 204.A, p.p. 139-168. (1904).

" Spectres de Flammes. Variations spectrales d'ordre thermique." Thèse présentée à la Faculté des Sciences de Paris. June 30th, 1904.

JOHN OSWALD WHITAKER. Born, April 2nd, 1870, at Hawes, Yorkshire.

1893-1896. Studied Electrical Engineering at the Owens College.

1896-1897. Assistant Engineer, The Edison & Swan Co., Broadheath.

1898-1899. Draughtsman (Electrical), The British Thomson Houston Co.

1899-1901. Assistant Engineer, The London United Electric Tramways, Ltd.

1901-1903. Overhead Tramways Equipment Engineer, Messrs. G. Hill & Co., Manchester.

Since 1903. Overhead Tramways Equipment Engineer, The Brush Electrical Engineering Co. Ltd.

JOHN WILD. Born, May 16th, 1869, at Bredbury, near Stockport.

1888-1890. Studied at the Owens College.

1890. B.Sc.

1891-1893. Studied at Tübingen University.

1895-1897. Research in the Physical Laboratories, also assisted in the early period of the application of X Rays for medical purposes.

Author, *in conjunction with* J. A. HARKER, of the following paper on work carried out in the laboratories :—

"Some Experiments on the Effect of Ultra-Violet Light on Chlorine and Hydrogen." *Electrician*, vol. 38, p.p. 690-692. (1897).

ARTHUR WESTLEY WILDRIDGE. Born, March 3rd, 1883, at Wellingborough.

1902-1905. Studied in the Honours School of Physics.

1905. B.Sc. (3rd Class Honours in Physics).

1905. Assistant Master under Stockport Education Committee.

Since 1906. Science Master at the Bournemouth School, Bournemouth.

HARRY EDWIN WOOD. Born, February 3rd, 1881, at Manchester.

1899-1902. Studied in the Honours School of Physics.

1902. B.Sc. (1st Class Honours in Physics).

1902-1903. Research Assistant to Professor Schuster.

1903-1905. Demonstrator in the Physical Laboratories of the Manchester University.

1906. Appointed Chief Assistant in the Transvaal Government Meteorological Department.

APPENDICES.

I. Subscriptions towards Building, Equipment and Endowment.

II. Inaugurated Lectures.

III. Graduates in the Honours School of Physics.

IV. Teaching Staff.

V. Records of some old Owens College Students.

Appendix I.

Subscriptions towards the Building, Equipment and Endowment of New Physical Laboratories.

Towards building.	£	s.	d.
A Friend	10,000	0	0
The late Mr. R. C. Christie	2,000	0	0
Captain Partington	2,000	0	0
Dr. Ludwig Mond	1,000	0	0
The late Mr. Henry Simon	1,000	0	0
Anonymous	1,000	0	0
The late Mr. J. P. Thomasson	1,000	0	0
The relatives of Dr. John Hopkinson, for erection of Electro-technical Laboratory..	1,894	0	0
Messrs. Platt Brothers, Ltd.	500	0	0
Lord Ashton	250	0	0
Mr. Neville Clegg	250	0	0
Mr. W. G. Groves	250	0	0
Mr. George W. Agnew	200	0	0
A Friend, through Sir Wm. Mather	200	0	0
Mr. W. H. Johnson	50	0	0
Mr. Alderman Thompson	50	0	0
	£21,644	0	0

Towards Equipment.			
The Lancashire County Council	500	0	0
Mr. Ivan Levinstein	500	0	0
Subscriptions towards equipment of John Hopkinson Memorial Laboratory (see list of subscribers below)	1,900	13	0

Sir Henry Roscoe, for purchase of Plant for liquefaction of air	£190	0	0
Mr. Edward Donner	120	0	0
Lord Egerton of Tatton	100	0	0
Mr. Thomas Gair Ashton	100	0	0
Sir T. Sebastian Bazley, Bart.	50	0	0
Mr. Walter Laverton	21	0	0
Mr. Ernest Schuster	20	0	0
	£3,501	13	0

TOWARDS ENDOWMENT FOR MAINTENANCE.

Mr. E. Donner	5,000	0	0

SUBSCRIPTIONS TOWARDS EQUIPMENT OF THE JOHN HOPKINSON MEMORIAL LABORATORY.

	£	s.	d.
Anonymous	500	0	0
Sir William Mather	250	0	0
Mr. W. J. Crossley, M.P. (gas engine) ..	200	0	0
The British Westinghouse Co. Ltd. (motor)..	130	0	0
Chloride Electric Storage Syndicate Limited (accumulators)	100	0	0
Linotype Company	100	0	0
Messrs. W. T. Glover & Co. Ltd. (cables) ..	100	0	0
Tudor Accumulator Company (accumulators)	80	0	0
The late Sir Henry Tate	50	0	0
Mr. Jesse Haworth	50	0	0
Messrs. Chance Bros.	50	0	0
Mr. J. T. Chance	50	0	0
Mr. F. J. Schuster	50	0	0

Messrs. Reddaway & Co. (belting)	£30	0	0
Mr. H. H. Smith-Carington	25	0	0
Mr. Alfred Haworth	25	0	0
Mr. Charles Pilkington	15	0	0
And in smaller sums	95	13	0
	£1,900	13	0

The total cost of the building and equipment to date has been over £36,500, a large portion of the deficit having been made up by a contribution from the Fund collected in Commemoration of the Jubilee of the Owens College.

Mention should also be made here of the John Harling Fellowship, founded in 1900 by a donation of £5,000 from Mr. R. H. Gibson and Mr. R. P. Blakeley, as legatees of Mr. John Harling.

Appendix II.

Series of Inauguration Lectures.

In the autumn of the year 1900, shortly after the opening of the new Laboratories, a series of Lectures was arranged to illustrate some of the principal advances in Physical Science during the 19th Century. These lectures served the useful purpose of bringing the work of the new laboratories and the general position of certain branches of Physics prominently before a large circle of friends of the University.

November 5th. Spectrum Analysis, by Professor Arthur Schuster, F.R.S.

November 12th. Planetary Discovery in the 19th Century, by Professor H. H. Turner, F.R.S.

November 19th. The Electric Light, by Professor F. G. FitzGerald, F.R.S.

November 26th. Electric Messages, by Sir Wm. Preece, K.C.B., F.R.S.

December 5th. Heat, by Sir Oliver Lodge, F.R.S.

December 10th. The Evolution of the Present Photographic Negative, by Sir Wm. Abney, K.C.B., F.R.S.

Appendix III.

List of students of the Owens College and University of Manchester who have graduated in the

Honours School of Physics:

	First Class.	Second Class.	Third Class.
1890.	Albert Griffiths.		E. E. D. Davis.
1892.			W. P. Steinthal.
1893.			T. C. Armitage.
1894.	J. D. Chorlton.		
1896.		W. B. Shaw.	
1897.			Edward Reeve.
1898.	William Mason.	James Lord.	
		Joseph Lustgarten.	
1899.		H. Morris-Airey.	John Tomlinson.
		Simon Rosenbaum.	
1900.	G. C. Simpson.	W. S. Brooks.	
		R. C. Wale.	
1901.		Douglas Farrar.	A. F. Quarmby.
1902.	A. S. Eddington.	F. A. Haigh.	
	J. W. Nicholson.	Edgar Sutcliffe.	
	H. E. Wood.		
1903.	L. N. Barker.		Harry Hirst.
	Travis Rimmer.	Thomas Wadsworth.	
	Fred. Unwin.		
1904.	R. E. Grime.		J. McL. Baldwin.
	J. G. Isherwood.		G. F. Douglas.
			John MacPherson.
1905.	J. R. Beard.	Harold Clarke.	Edith L. Hewlett.
			A. W. Wildridge.

Appendix IV.

Teaching Staff of the Physical Laboratories.

[April, 1906.]

Langworthy Professor of Physics and Director of the Laboratories. Arthur Schuster, Ph.D., M.Sc., Sc.D., F.R.S. (Appointed 1888).

Assistant-Director of the Laboratories and Senior Lecturer. Charles H. Lees, D.Sc., F.R.S. (Appointed 1891).

Demonstrator and Lecturer in Electrical Engineering. Robert Beattie, D.Sc. (Appointed 1896).

Demonstrator and Lecturer in Electro-Chemistry. R. S. Hutton, D.Sc. (Appointed 1900).

Lecturer on Meteorology. G. C. Simpson, M.Sc. (Appointed 1905).

Demonstrators and Assistant Lecturers. Herbert Stansfield, B.Sc. (Appointed 1906). Sidney Russ, B.Sc. (Appointed 1906).

Former Professors.

Appointed	1851.	Archibald Sandeman; resigned 1860. (Deceased).
,,	1860.	R. B. Clifton, M.A., F.R.S.; resigned 1886. (Now Professor in the University of Oxford).
,,	1866.	William Jack, M.A.; resigned 1870. (Now Professor in the University of Glasgow).
,,	1870.	Balfour Stewart, M.A., LL.D., F.R.S. (Deceased).
,,	1870.	T. H. Core, M.A.; resigned 1905.

Former Demonstrators and Lecturers.

Appointed	1870.	Francis Kingdon; resigned 1876.
,,	1873.	Arthur Schuster. Ph.D.. F.R.S. (Honorary Demonstrator): resigned 1876.
,,	1876.	J. H. Poynting, Sc.D.. F.R.S.; resigned 1879. (Now Professor in the University of Birmingham).
,,	1881.	W. W. Haldane Gee, B.Sc.; resigned 1891. (Now Professor in the Manchester School of Technology).
,,	1889.	H. E. Hadley, B.Sc.; resigned 1892. (Now Headmaster of Kidderminster School of Science).
,,	1892.	W. G. Rhodes, D.Sc.; resigned 1894. (Now Lecturer in the Royal Technical Institute Salford).
,,	1893.	J. W. Pickles Hayton, B.Sc.; resigned 1895.
,,	1894.	William Gannon, M.A.; resigned 1896. (Now Director of the Woolwich Polytechnic)
,,	1895.	Albert Griffiths, D.Sc.; resigned 1898. (Now Head of Physics Department, Birbeck College, London).
,,	1896.	Robert Beattie, D.Sc.; in 1900 appointed Lecturer in Electrical Engineering.
,,	1898.	S. R. Milner, D.Sc.; resigned 1900. (Now Lecturer in Physics, Sheffield University).
,,	1900.	James Lord, M.Sc.; resigned 1903.
,,	1900.	R. C. Wale, B.Sc.; resigned 1903. (Now Assistant at H.M. Patent Office, London).
,,	1903.	H. E. Wood, M.Sc.; resigned 1906. (Now Chief Assistant, Transvaal Government Meteorological Observatory).
,,	1903.	Harold Morris-Airey, M.Sc.; resigned 1906. (Now Lecturer in Physics, Armstrong College, Newcastle-on-Tyne).

Appendix V.

The following brief records, showing the connection of certain well known physicists and engineers with the Owens College, are included in this volume, although they do not, in most cases, fall distinctly within the period which it has been desired to cover. They have, however, all either come in contact with Dr. Schuster whilst he was acting as Honorary Demonstrator, or have been pupils of his distinguished predecessors.

Arthur William Brightmore, D.Sc. (Manchester). M.I.C.E.
Born May 9th, 1864 at Manchester.

1879-1883. Engineering Course at Owens College, including Physics and Applied Mathematics, obtained Fairbairn Engineering Prize, a Dalton Mathematical Scholarship, and was in 1883 Elected to a Bishop Berkeley Fellowship.

1883. B.Sc. (1st Class Honours in Engineering).

1883-1888. Serving Articles and Assistant Engineer.

1888-1894. Resident Engineer on New Aqueduct Liverpool Waterworks.

1894-1899. Resident Engineer on New Aqueduct, Birmingham Waterworks.

1896. Elected Member of the Institution of Civil Engineers; has received a "Manby" and a 'Telford" Premium for papers communicated to the Institution.

1898. D.Sc. (Manchester).

Since 1899. Professor of Engineering at the Royal Indian Engineering College, Coopers Hill.

John Walton Capstick, M.A. (Cambridge), D.Sc. (Manchester).
Born August 31st, 1858 at Lancaster.

1880-1883. Student at the Owens College.

1882. Senior Dalton Mathematical Scholar.

1883. B.Sc. (1st Class Honours in Mathematics), and Derby Scholarship.

1883-1888. Assistant Lecturer in Mathematics and Physics, University College, Dundee.

1891. B.A. (Cambridge). 1st Class Natural Science Tripos. Assistant Demonstrator in the Cavendish Laboratory.

1893. D.Sc. (Manchester).

1893. Fellow of Trinity College, Cambridge.

1895. Lecturer, Trinity College.

Since 1898. Junior Bursar, Trinity College.

ERNEST HOWARD GRIFFITHS, M.A., Sc.D. (Cambridge). Hon. D.Sc. (Manchester). F.R.S. Ex-Vice-Chancellor of the University of Wales. Born June 15th, 1851 at Brecon.

From 1868 to 1870. Studied at the Owens College, commencing the study of Physics under Professor Jack.

1870. Entered Sidney Sussex College, Cambridge.

1897. Elected Fellow of Sidney Sussex.

1895. Elected Fellow of the Royal Society.

Since 1901. Principal and Professor of Physics University College, Cardiff.

1903. Elected Honorary Fellow of Sidney Sussex College.

1905. Fellow of Jesus College, Oxford.

1906. President of Section A, British Association.

EDWARD HOPKINSON, M.A. (Cambridge). D.Sc. (London). B.Sc. (Manchester). Born May 28th, 1859 in Manchester.

1874-1877. Studied at Owens College under Professor Barker, the late Professor Balfour Stewart, Dr. Schuster and Sir Henry Roscoe.

1874. Dalton Mathematical Exhibition at Owens College.

1877. Entrance Scholarship at Emmanuel College, Cambridge.

1878. Mathematical Foundation Scholarship at Emmanuel College, Cambridge.

1881. 10th Wrangler.

1883. Fellow of Emmanuel College, Cambridge.

1881. D.Sc. (London), in the Branch of Electricity treated Mathematically.

1882-1883. Assistant to the late Sir Wm. Siemens, superintending the erection of the first electric railway in the United Kingdom, at Portrush.

1884. Entered the firm of Messrs. Mather & Platt, taking charge of the electrical department. Subsequently became partner and is now Vice-Chairman of Mather & Platt, Ltd., as also of the Chloride Electric Storage Co. Ltd.

1890. Elected Member of the Institution of Civil Engineers, of which he has been awarded the "Telford" Premium and Medal, and the "George Stephenson" medal.

Member of Council of Instit. of Mechanical Engineers, and has served on the Council of the Instit. of Electrical Engineers.

For some time Chairman of the Associates of Owens College, and now Member of the Court of the Manchester University.

HENRY STROUD, M.A. (Cambridge and Durham), D.Sc, (London and Durham). Born August 7th, 1861, at Bristol.

1880-1882. Studied at the Owens College, holding the Gilchrist and Heginbottom Scholarships.

Subsequently at St. John's College, Cambridge.

1885. Bracketed 8th Wrangler.

1886. 1st Class Natural Science Tripos. Part II.

Since 1887. Professor of Physics in Armstrong College of Science, Newcastle-on-Tyne.

WILLIAM STROUD, M.A. (Oxford). D.Sc. (London). Born February 2nd, 1860, at Bristol.

From 1879-1881. Studied at the Owens College, holding the Heginbottom Scholarship in Physics.

Subsequently at Oxford, Heidelberg and Würzburg.

Since 1885. Professor of Physics at the Yorkshire College, now the University, Leeds.

JOSEPH JOHN THOMSON, M.A. (Cambridge), Hon. Sc.D. (Dublin), Hon. D.Sc. (Manchester), Hon. LL.D. (Glasgow), F.R.S. Born December 18th, 1850, in Manchester.

1871-1876. Study and Research in the Physical Laboratories at the Owens College, publishing his first scientific paper, "Experiments on Contact Electricity between Non-Conductors," *Proc. Roy. Soc.* vol. 25 p.p. 169-171. (1876).

1876. Entered Trinity College, Cambridge.

1880. 2nd Wrangler and 2nd Smith's Prizeman, also Fellow of Trinity College.

1883. Lecturer in Mathematics at Trinity College.

1884. Elected Fellow of Royal Society.

Since 1884. Professor of Experimental Physics at Cambridge.

1894. Royal Medallist of the Royal Society.

1900. Honorary D.Sc. (Manchester).

1900-1903. Representative of the Associates on the Court of Governors of the Owens College.

1902. Hughes Medallist of the Royal Society.

Since 1905. Professor of Natural Philosophy at the Royal Institution, London.

THOMAS MATHER, F.R.S. Born December 15th, 1856, at Higher Walton, near Preston.

1878-1881. Studied at the Owens College.

1878. First Whitworth Scholar.

1880. Ashbury Engineering Scholarship.

1881. Engineering Certificate with Honours in Mathematics and Engineering.

1881-1882. Studied at the Normal School of Science, South Kensington, as Royal Exhibitioner.

1882-1885. Assistant to Professor Ayrton at Finsbury Technical College.

Since 1885. Chief Assistant in the Electrical Engineering Department at the Central Technical College, South Kensington.

1902. Elected Fellow of the Royal Society.

JOHN HENRY POYNTING, Sc.D. (Cambridge). Hon. D.Sc. (Manchester). F.R.S. Born September 9th, 1852, at Monton, near Manchester.

1867-1872. Studied at the Owens College, being one of the first students when the Physical Laboratory was opened.

1872. Entered Trinity College, Cambridge.

1876. 3rd. Wrangler.

1876-1879. Demonstrator in Physics at the Owens College.

1878. Fellow of Trinity College.

1888. Elected Fellow of the Royal Society.

Since 1880. Professor of Physics at the Mason College, now the University of Birmingham.

The following paper was published on work carried out at the Owens College :—

"On a method of using the Balance with great delicacy, and on its employment to determine the Mean Density of the Earth." *Proc. Roy. Soc.* vol. 28, p.p. 2-35 (1878).

CHARLES THOMSON REES WILSON, M.A. (Cambridge). B.Sc. (Manchester). F.R.S. Born at Glencorse, Midlothian, February 14th. 1869.

1884-1887. Studied at the Owens College.

1887. B.Sc.

Subsequently entered Sidney Sussex College, Cambridge.

1890-1892. 1st Class Natural Science Tripos. Parts I and II.

Since 1895. Engaged in Research in the Cavendish Laboratory, Cambridge; University Lecturer and Demonstrator in Physics.

Since 1900. Fellow of Sidney Sussex College, Cambridge.

1900. Elected Fellow of the Royal Society.

ARTHUR MASON WORTHINGTON, C.B., M.A. (Oxford). F.R.S., F.R.A.S. Born June 11th, 1852, at Manchester.

At Trinity College, Oxford. (M.A.)

Subsequently studied under Professor Balfour Stewart and Sir Henry Roscoe at Owens College for intervals, from 1875-1877.

1877. In the Laboratory of Helmholtz, at Berlin.

Since 1888. Headmaster and Professor of Physics, Royal Naval Engineering College, Devenport.

1893. Elected Fellow of the Royal Society.

1902. Appointed C.B.

Appendix III.

List of students of the Owens College and University of Manchester who have graduated in the

Honours School of Physics:

	First Class.	Second Class.	Third Class.
1890.	Albert Griffiths.		E. E. D. Davis.
1892.			W. P. Steinthal.
1893.			T. C. Armitage.
1894.	J. D. Chorlton.		
1896.		W. B. Shaw.	
1897.			Edward Reeve.
1898.	William Mason.	James Lord.	
		Joseph Lustgarten.	
1899.		H. Morris-Airey.	John Tomlinson.
		Simon Rosenbaum.	
1900.	G. C. Simpson.	W. S. Brooks.	
		R. C. Wale.	
1901.		Douglas Farrar.	A. F. Quarmby.
1902.	A. S. Eddington.	F. A. Haigh.	
	J. W. Nicholson.	Edgar Sutcliffe.	
	H. E. Wood.		
1903.	L. N. Barker.		Harry Hirst.
	Travis Rimmer.	Thomas Wadsworth.	
	Fred. Unwin.		
1904.	R. E. Grime.		J. McL. Baldwin.
	J. G. Isherwood.		G. F. Douglas.
			John MacPherson.
1905.	J. R. Beard.	Harold Clarke.	Edith L. Hewlett.
			A. W. Wildridge.

Appendix IV.

Teaching Staff of the Physical Laboratories.

[April, 1906.]

Langworthy Professor of Physics and Director of the Laboratories. Arthur Schuster, Ph.D., M.Sc., Sc.D., F.R.S. (Appointed 1888).

Assistant-Director of the Laboratories and Senior Lecturer. Charles H. Lees, D.Sc., F.R.S. (Appointed 1891).

Demonstrator and Lecturer in Electrical Engineering. Robert Beattie, D.Sc. (Appointed 1896).

Demonstrator and Lecturer in Electro-Chemistry. R. S. Hutton, D.Sc. (Appointed 1900).

Lecturer on Meteorology. G. C. Simpson, M.Sc. (Appointed 1905).

Demonstrators and Assistant Lecturers. Herbert Stansfield, B.Sc. (Appointed 1906). Sidney Russ, B.Sc. (Appointed 1906).

Former Professors.

Appointed	1851.	Archibald Sandeman; resigned 1860. (Deceased).
,,	1860.	R. B. Clifton, M.A., F.R.S.; resigned 1886. (Now Professor in the University of Oxford).
,,	1866.	William Jack, M.A.; resigned 1870. (Now Professor in the University of Glasgow).
,,	1870.	Balfour Stewart, M.A., LL.D., F.R.S. (Deceased).
,,	1870.	T. H. Core, M.A.; resigned 1905.

Former Demonstrators and Lecturers.

Appointed	1870.	Francis Kingdon; resigned 1876.
,,	1873.	Arthur Schuster, Ph.D., F.R.S. (Honorary Demonstrator); resigned 1876.
,,	1876.	J. H. Poynting, Sc.D., F.R.S.; resigned 1879. (Now Professor in the University of Birmingham).
,,	1881.	W. W. Haldane Gee, B.Sc.; resigned 1891. (Now Professor in the Manchester School of Technology).
,,	1889.	H. E. Hadley, B.Sc.; resigned 1892. (Now Headmaster of Kidderminster School of Science).
,,	1892.	W. G. Rhodes, D.Sc.; resigned 1894. (Now Lecturer in the Royal Technical Institute Salford).
,,	1893.	J. W. Pickles Hayton, B.Sc.; resigned 1895.
,,	1894.	William Gannon, M.A.; resigned 1896. (Now Director of the Woolwich Polytechnic)
,,	1895.	Albert Griffiths, D.Sc.; resigned 1898. (Now Head of Physics Department, Birbeck College, London).
,,	1896.	Robert Beattie, D.Sc.; in 1900 appointed Lecturer in Electrical Engineering.
,,	1898.	S. R. Milner, D.Sc.; resigned 1900. (Now Lecturer in Physics, Sheffield University).
,,	1900.	James Lord, M.Sc.; resigned 1903.
,,	1900.	R. C. Wale, B.Sc.; resigned 1903. (Now Assistant at H.M. Patent Office, London).
,,	1903.	H. E. Wood, M.Sc.; resigned 1906. (Now Chief Assistant, Transvaal Government Meteorological Observatory).
,,	1903.	Harold Morris-Airey, M.Sc.; resigned 1906. (Now Lecturer in Physics, Armstrong College, Newcastle-on-Tyne).

Appendix V.

The following brief records, showing the connection of certain well known physicists and engineers with the Owens College, are included in this volume, although they do not, in most cases, fall distinctly within the period which it has been desired to cover. They have, however, all either come in contact with Dr. Schuster whilst he was acting as Honorary Demonstrator, or have been pupils of his distinguished predecessors.

Arthur William Brightmore, D.Sc. (Manchester). M.I.C.E.
Born May 9th, 1864 at Manchester.

1879-1883. Engineering Course at Owens College, including Physics and Applied Mathematics, obtained Fairbairn Engineering Prize, a Dalton Mathematical Scholarship, and was in 1883 Elected to a Bishop Berkeley Fellowship.

1883. B.Sc. (1st Class Honours in Engineering).

1883-1888. Serving Articles and Assistant Engineer.

1888-1894. Resident Engineer on New Aqueduct Liverpool Waterworks.

1894-1899. Resident Engineer on New Aqueduct, Birmingham Waterworks.

1896. Elected Member of the Institution of Civil Engineers; has received a "Manby" and a 'Telford" Premium for papers communicated to the Institution.

1898. D.Sc. (Manchester).

Since 1899. Professor of Engineering at the Royal Indian Engineering College, Coopers Hill.

John Walton Capstick, M.A. (Cambridge), D.Sc. (Manchester).
Born August 31st, 1858 at Lancaster.

1880-1883. Student at the Owens College.

1882. Senior Dalton Mathematical Scholar.

1883. B.Sc. (1st Class Honours in Mathematics), and Derby Scholarship.

1883-1888. Assistant Lecturer in Mathematics and Physics, University College, Dundee.

1891. B.A. (Cambridge). 1st Class Natural Science Tripos. Assistant Demonstrator in the Cavendish Laboratory.

1893. D.Sc. (Manchester).

1893. Fellow of Trinity College, Cambridge.

1895. Lecturer, Trinity College.

Since 1898. Junior Bursar, Trinity College.

ERNEST HOWARD GRIFFITHS, M.A., Sc.D. (Cambridge). Hon. D.Sc. (Manchester). F.R.S. Ex-Vice-Chancellor of the University of Wales. Born June 15th, 1851 at Brecon.

From 1868 to 1870. Studied at the Owens College, commencing the study of Physics under Professor Jack.

1870. Entered Sidney Sussex College, Cambridge.

1897. Elected Fellow of Sidney Sussex.

1895. Elected Fellow of the Royal Society.

Since 1901. Principal and Professor of Physics University College, Cardiff.

1903. Elected Honorary Fellow of Sidney Sussex College.

1905. Fellow of Jesus College, Oxford.

1906. President of Section A, British Association.

EDWARD HOPKINSON, M.A. (Cambridge). D.Sc. (London). B.Sc. (Manchester). Born May 28th, 1859 in Manchester.

1874-1877. Studied at Owens College under Professor Barker, the late Professor Balfour Stewart, Dr. Schuster and Sir Henry Roscoe.

1874. Dalton Mathematical Exhibition at Owens College.

1877. Entrance Scholarship at Emmanuel College, Cambridge.

1878. Mathematical Foundation Scholarship at Emmanuel College, Cambridge.

1881. 10th Wrangler.

1883. Fellow of Emmanuel College, Cambridge.

1881. D.Sc. (London), in the Branch of Electricity treated Mathematically.

1882-1883. Assistant to the late Sir Wm. Siemens, superintending the erection of the first electric railway in the United Kingdom, at Portrush.

1884. Entered the firm of Messrs. Mather & Platt, taking charge of the electrical department. Subsequently became partner and is now Vice-Chairman of Mather & Platt, Ltd., as also of the Chloride Electric Storage Co. Ltd.

1890. Elected Member of the Institution of Civil Engineers, of which he has been awarded the "Telford" Premium and Medal, and the "George Stephenson" medal.

Member of Council of Instit. of Mechanical Engineers, and has served on the Council of the Instit. of Electrical Engineers.

For some time Chairman of the Associates of Owens College, and now Member of the Court of the Manchester University.

HENRY STROUD, M.A. (Cambridge and Durham), D.Sc, (London and Durham). Born August 7th, 1861, at Bristol.

1880-1882. Studied at the Owens College, holding the Gilchrist and Heginbottom Scholarships.

Subsequently at St. John's College, Cambridge.

1885. Bracketed 8th Wrangler.

1886. 1st Class Natural Science Tripos. Part II.

Since 1887. Professor of Physics in Armstrong College of Science, Newcastle-on-Tyne.

WILLIAM STROUD, M.A. (Oxford). D.Sc. (London). Born February 2nd, 1860, at Bristol.

From 1879-1881. Studied at the Owens College, holding the Heginbottom Scholarship in Physics.

Subsequently at Oxford, Heidelberg and Würzburg.

Since 1885. Professor of Physics at the Yorkshire College, now the University, Leeds.

JOSEPH JOHN THOMSON, M.A. (Cambridge). Hon. Sc.D. (Dubiln). Hon. D.Sc. (Manchester). Hon. LL.D. (Glasgow). F.R.S. Born December 18th, 1856, in Manchester.

1871-1876. Study and Research in the Physical Laboratories at the Owens College, publishing his first scientific paper, 'Experiments on Contact Electricity between Non-Conductors.' *Proc. Roy. Soc.* vol. 25 p.p. 169-171. (1876).

1876. Entered Trinity College, Cambridge.

1880. 2nd Wrangler and 2nd Smith's Prizeman, also Fellow of Trinity College.

1883. Lecturer in Mathematics at Trinity College.

1884. Elected Fellow of Royal Society.

Since 1884. Professor of Experimental Physics at Cambridge.

1894. Royal Medallist of the Royal Society.

1900. Honorary D.Sc. (Manchester).

1900-1903. Representative of the Associates on the Court of Governors of the Owens College.

1902. Hughes Medallist of the Royal Society.

Since 1905. Professor of Natural Philosophy at the Royal Institution, London.

THOMAS MATHER, F.R.S. Born December 15th, 1856, at Higher Walton, near Preston.

1878-1881. Studied at the Owens College.

1878. First Whitworth Scholar.

1880. Ashbury Engineering Scholarship.

1881. Engineering Certificate with Honours in Mathematics and Engineering.

1881-1882. Studied at the Normal School of Science, South Kensington, as Royal Exhibitioner.

1882-1885. Assistant to Professor Ayrton at Finsbury Technical College.

Since 1885. Chief Assistant in the Electrical Engineering Department at the Central Technical College, South Kensington.

1902. Elected Fellow of the Royal Society.

JOHN HENRY POYNTING, Sc.D. (Cambridge). Hon. D.Sc. (Manchester). F.R.S. Born September 9th, 1852, at Monton, near Manchester.

1867-1872. Studied at the Owens College, being one of the first students when the Physical Laboratory was opened.

1872. Entered Trinity College, Cambridge.

1876. 3rd. Wrangler.

1876-1879. Demonstrator in Physics at the Owens College.

1878. Fellow of Trinity College.

1888. Elected Fellow of the Royal Society.

Since 1880. Professor of Physics at the Mason College, now the University of Birmingham.

The following paper was published on work carried out at the Owens College :—

"On a method of using the Balance with great delicacy, and on its employment to determine the Mean Density of the Earth." *Proc. Roy. Soc.* vol. 28, p.p. 2-35 (1878).

CHARLES THOMSON REES WILSON, M.A. (Cambridge). B.Sc. (Manchester). F.R.S. Born at Glencorse, Midlothian, February 14th. 1869.

1884-1887. Studied at the Owens College.

1887. B.Sc.

Subsequently entered Sidney Sussex College, Cambridge.

1890-1892. 1st Class Natural Science Tripos. Parts I and II.

Since 1895. Engaged in Research in the Cavendish Laboratory, Cambridge; University Lecturer and Demonstrator in Physics.

Since 1900. Fellow of Sidney Sussex College, Cambridge.

1900. Elected Fellow of the Royal Society.

ARTHUR MASON WORTHINGTON, C.B., M.A. (Oxford). F.R.S., F.R.A.S. Born June 11th, 1852, at Manchester.

At Trinity College, Oxford. (M.A.)

Subsequently studied under Professor Balfour Stewart and Sir Henry Roscoe at Owens College for intervals, from 1875-1877.

1877. In the Laboratory of Helmholtz, at Berlin.

Since 1888. Headmaster and Professor of Physics, Royal Naval Engineering College, Devenport.

1893. Elected Fellow of the Royal Society.

1902. Appointed C.B.

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